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THE NEW MORRISON STREET BRIDGE, PORTLAND, OREGON.

By H. A. Crafts.

The Morrison Street bridge, Portland, Oregon, completed in the early part of 1905, is one of the largest public bridges in the United States west of the Rocky Mountains.

It crosses the Willamette River, and forms the main artery between the east and west sides of Portland. The old bridge, which the new one was built to replace, had become quite inadequate to the requirements of the day. The earlier bridge was built in the early eighties. It consisted of four combination spans and a steel draw 308 feet long.

The particular difficulties to be overcome in the removal of the old structure and construction of the new were: First, that a large volume of traffic must be provided for, with no considerable interruption; second, that navigation had to be kept open; and third, that the substructural work had to be carried on in the main channel, amounting to 60 feet at its lowest stage.

The new bridge was built under provisions of a special act of the legislature, which gave the city of Portland power to bond itself to the extent of $400,000 for its construction. The contract for the work was let to the Pacific Construction Company, of San Francisco, and work was begun in November, 1903, and the bridge was finished in January, 1905. The new bridge is a modern structure, consisting of a 200-foot span at the west end, a 384-foot draw, and two 269-foot spans. The piers under the fixed spans are Cushing piers, the cylinders being 14 feet in diameter up to a point above low-water line, and 9 feet in diameter in top section.

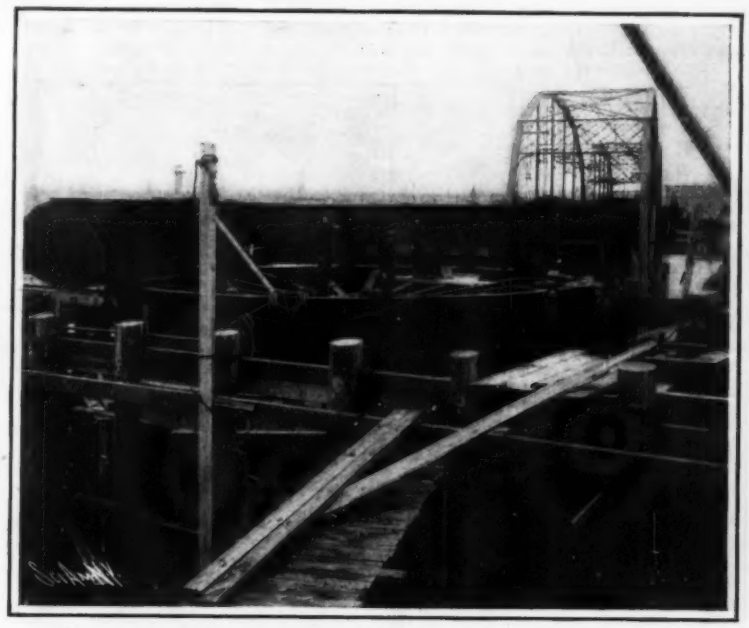
The center pier, which was in 60 feet of water at the river's lowest stage, is composed of a foundation of 256 piles, which were driven with a 4,600-pound hammer to depths varying from 33 to 48 feet below the river bottom. In order to insure stability in this foundation, it was desirable to cut the piles off as close to the bottom of the river as possible, and it was absolutely necessary that they should be cut off to a true level. To do this the contractors designed a rig consisting of a carriage, running on tracks, built upon solid falsework, on which was placed another carriage working across the first. Suspended from this upper carriage was a four-post steel frame, built of angles and rods, extending down to the required depth, and on one corner of this was carried the shaft, to which was attached a five-foot circular saw. This saw was operated by an electric motor, and by its careful operation the piles were cut off to a true level.

On the top of the pile foundation was placed a grillage, made of surfaced 12 x 12 timbers, the three lowest courses being built up solid and thoroughly bolted with screw and drift bolts. The greater portion of the grillage was built on shore, launched, and towed to place.

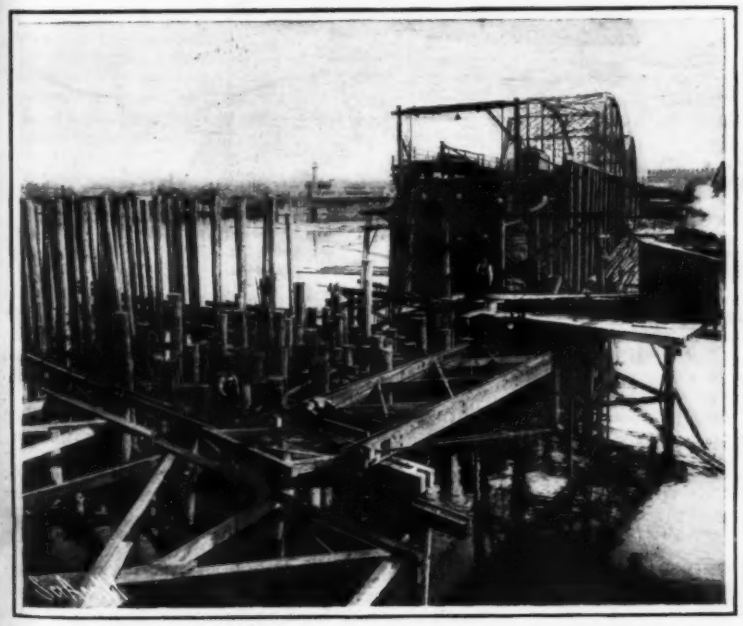
Piles were then driven around the foundation, to which were attached 12 x 12 spuds, three on each side, which were so arranged as to hold the grillage in exact position and to guide it as it sunk. The timber base thus formed was 51 feet square.

After the base was in position, open courses of 12 x 12 timbers with openings about 9 inches wide were laid and securely drift-bolted, one course to another; and as built up this whole mass was sub-

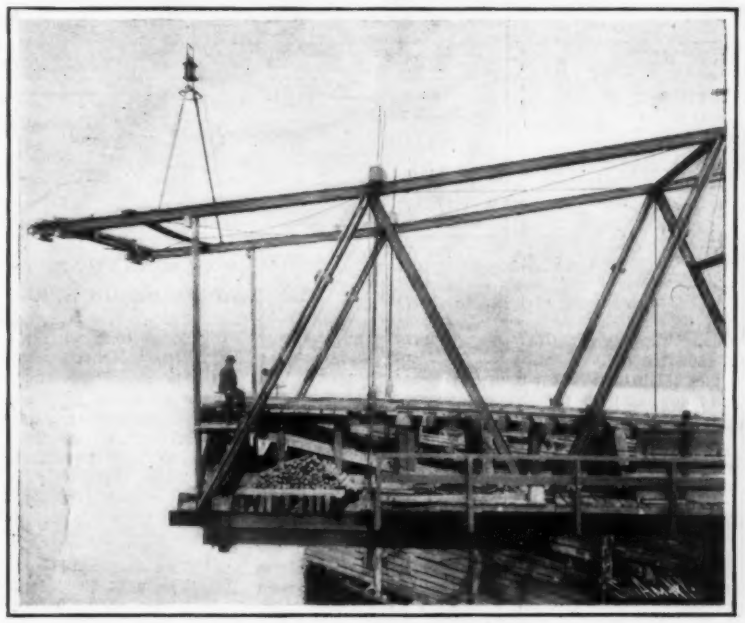
TOP OF THE CENTER PIER READY FOR TURNTABLE TRACKS.



THE MAIN LOADING BEAM OF THE TURNTABLE.



THE RIG FOR CUTTING OFF PILES UNDER 60 FEET OF WATER.



WESTERLY END OF THE OLD DRAW AFTER THE 40-FOOT SECTION HAD BEEN REMOVED, SHOWING COUNTERWEIGHT AND INCLINE FOR CARS.

THE NEW MORRISON STREET BRIDGE, PORTLAND, OREGON.

merged by loading with gravel. The three top courses were solid, as were the three base courses. This timber grillage reached to within three feet of low-water mark. On top of this grillage was erected a steel cylinder 46 feet in diameter and about 30 feet high, which was filled with concrete. On the top of the pier thus formed was erected the turntable and turning machinery for operating the drawspan.

In removing the old fixed spans and erecting the new, a six-post traveler was used, the materials being brought to the site upon cars from a storage yard on the railroad switch some six blocks distant. Careful measures were taken by the contractors to permit the passage of cars and pedestrians during the period of construction, which made it necessary to raise the tracks some six feet over the falsework for the fixed spans, and provide an incline from the old drawspan. This was necessary in order to place the new floor beams in position, the new floor being some four feet higher than the old floor.

In order to build the westerly span without stopping traffic it became necessary to cut off 40 feet of the old drawspan. This was done during a single night, and the connection made and the draw operated in this shape for a considerable period, it being kept in balance by counter-weights.

It was the original design of the contractors to cut off 70 feet of the easterly end of the old draw, so as to prevent the building of the center pier causing an interruption of traffic; but because of the interference of the United States government, the city permitted the closing of the bridge to traffic for 42 days, during which time the old draw was removed and the new one constructed.

The old bridge had a roadway 21 feet in width, and two sidewalks; the new has a roadway 36 feet in width and two seven-foot sidewalks.

The price paid to the contractors for the construction of this bridge was $381,573.

VIEW OF THE 269-FOOT SPANS FROM THE SWING SPAN.

THE NEW MORRISON STREET BRIDGE, PORTLAND, OREGON.

LARGE ELECTRIC AND STEAM LOCOMOTIVES.*

FREIGHT HELPER ELECTRIC LOCOMOTIVES.

IN discussing matters of this kind, it is important to know the practical results from actual operation and maintenance, and a report of the comparative performance of electric and steam locomotives in actual service during the past year may be of interest.

Due to certain conditions, the Baltimore & Ohio Railroad now has in its service six electric locomotives.

Numbers 1, 2, and 3, each having a total weight of 196,000 pounds carried on four pairs of driving wheels, and number 4, a small switching locomotive, have all been in service for the past ten years.

Numbers 5-6 and 7-8, put into service about September, 1903, are specially designed freight train helping locomotives, each having a total weight in working order of 160 tons (80 tons per section), distributed over 16 driving wheels (8 per section), with a total wheel base of 44 feet 2¾ inches (14 feet 6¾ inches per section), and two 14 feet 6¾ inches rigid wheel bases.

The driving wheels are 42 inches in diameter, each pair being geared to a 200-horse-power, 625-volt motor, with a ratio of gearing 81 to 19, providing for a total tractive effort at full working load on 8 motors of 70,000 pounds, and at starting of 80,000 pounds, assuming 25 per cent tractive coefficient, giving a nominal rating of 1,600 horse-power.

These locomotives are equipped with electric air compressors for the operation of the brake, signal, third rail safety cut-out switches, track sander, bell and whistle, and also with the usual steam locomotive equipment.

The source of power is a central steam plant generating direct current at 560 volts, from which it is transmitted through feed cables direct to the booster stations, where the voltage is increased to 625, and the current then conveyed to a storage battery which is used as a reserve and for peak loads, as well as to a surface third rail system of contact line, equipped with safety cut-out device. The locomotive motors obtain about one-half the required current direct from each of the storage and booster stations.

The free running speed of these locomotives is about 20 miles per hour. On a level track, with good current, rail and weather conditions, they are capable of starting and accelerating a train weighing 3,000 tons with a current consumption of 2,200 amperes, which consumption, when speed increases to and is maintained at about 10 miles per hour, reduces to about 900 amperes.

On a 1 per cent grade these locomotives, under similar conditions, will start and accelerate a train weighing 1,400 tons with a current consumption of 2,200 amperes, which consumption, when speed increases to and is maintained at about 10 miles per hour, reduces to about 1,600 amperes.

These locomotives handle eastbound through freight steam locomotives and trains at Baltimore, Md., from Camden Yard to Waverly, a distance of a little over 3.4 miles, returning light. This distance includes seven curves, ranging from 5 to 11 degrees; seven tunnels from 400 feet to 7,000 feet in length, and gradients about as follows:

The first 9,000 feet averages	1.0 per cent
The next 2,000 feet averages	1.4 per cent
The next 2,500 feet averages	1.5 per cent
And the next 4,500 feet averages	0.8 per cent

The time consumed when hauling freight trains weighing 1,395 tons in cars of various capacities and lading, 105 tons in steam locomotives and 160 tons in electrical locomotives, or a total moving load of 1,660 tons, averages 23 minutes actual running time from start until the electric helper locomotive cuts from head end of the train to return light.

During the past one year's service the combined mileage of the four sections comprising these two electric locomotives has been 121,015 miles, computed on the basis of straight light and loaded mileage. The proportion of light and loaded mileage was half and half, and about 200 miles per month per locomotive of one section was in passenger helper service.

Each section contributes its individual mileage for the distance run, whether it is operated singly, or in connection with one, two, or three similar sections or other electric locomotives, although the general practice is that two similar sections are operated in tandem. Therefore, the average miles run per locomotive of two sections per month would be 2,521 miles, which is the figure that must be taken in comparison with the operation of the steam locomotive to be described.

Considering $1.25 per net ton as a base cost for fuel delivered at the power plant, the average total operating and maintenance expenses during the year for generating current; the labor and material for locomotive electrical and mechanical repairs; the engineer's wages; wiping, hostlering, inspecting, oiling, and dispatching; lubricating and miscellaneous supplies, was approximately $69 per 100 miles run per locomotive of two sections. Of this amount the average cost of labor and material applied to each locomotive for the running and shop repairs would be $6.40, or 52 per cent for the electrical, and $5.80, or 48 per cent for the mechanical, making a total average cost of $12.20 per 100 miles run for both the electrical and mechanical repairs.

The above figures do not take into consideration interest, depreciation, taxes, nor insurance on the investment, nor do they include the expense incident to the maintenance of such equipment as battery, feeders, third rail, bonding wires, insulation, safety cut-out switches, extra motors, etc., which is not required for steam locomotive operation. The wages for the conductor, or second man on the locomotive, has also been omitted.

During their service considerable difficulty has been experienced with the shoes used for collecting the current from the surface third rail; the loosening and wear of pinions used to transmit the power from the motors to the gears on the driving wheel axles; breakage of gears on driving wheel axles; the lubrication, heating, and wear at the armature bearings; the flange and tread wear of driving wheel tire; derailments; stalling and breaking in two of freight trains due to slipping of driving wheels, more especially with wet rails, or when tires of drivers connected in series are not of exact diameters, and in miscellaneous renewals and shop repairs.

The driving wheel tires which, when new, were 2⅞ inches thick, are now 1¾ inches thick, showing only 7,500 miles run per 1-16 inch of metal removed at the tread, and will have to be renewed within a few months. (Note.—Since this report was written locomotive sections 5, 6 and 7 have had all driving wheel tires renewed.)

From experience, to the present date it would appear that an electric locomotive and its source of power, to produce the proper efficiency and economy in operation for either passenger, freight, or helper service, should fulfill the following essential requirements:

1. A fire and collision resisting locomotive construction within the present clearance and weight limits; simple in design; reasonable in first cost; safe, reliable, and economical for operation at varying speeds and power; and accessible for inspection, lubrication, cleaning, repairs, and for replacement on a track in event of derailment of any or all wheels, by the ordinary steam locomotive and car methods, without the necessity for the use of a power crane.

2. A locomotive that can be interchanged and oper-

* A paper read before the New York Railroad Club by Mr. J. E. Muhlfeld, general superintendent of motive power, Baltimore and Ohio Railroad.

ated over home and foreign tracks which are suitable for steam locomotive or motor car equipment.

3. A locomotive composed of two or more interchangeable sections, each a duplicate of the other, and equipped so that each section may be operated from either end, and independently or jointly, with any number of coupled sections; the operation under any arrangement to be controlled from a single section by one engineer.

4. The elimination of pilot wheels and the concentration of the entire weight on the driving wheels, with a minimum weight per wheel at the rail of 25,000 pounds; and an arrangement of driving wheels providing for a short rigid and a long flexible wheel base, without excessive end play at axle bearings.

5. The elimination of armatures from locomotive driving wheel axles and the transmission of power to driving wheels not less than 60-inch initial diameter without the use of gearing, in a manner that will insure the economical use of current at the motors for starting and running, and eliminate the accumulation of unbalanced pressure at the wheel and rail contacts, as well as the independent revolution of one or more pairs of driving wheels when coupled in series, which occurs as the driving wheels become slightly different in diameter due to ordinary wear or material, when making transition in current at motors, or when operating on slippery track or over rails, frogs, and switches of varying wear, surface, alignment, and elevation.

6. The least weight between the track and the locomotive frame carrying springs, to minimize the pressures, lateral thrusts, and wear at the rail and wheel flanges.

7. A high center of gravity, so that the vibration of the locomotive, due to the variation in surface, alignment, elevation, and curvature of track, can be absorbed by the weight suspended over the driving springs.

8. A proper proportion between the electrical, mechanical, and dead equipment weights of the locomotive.

9. Locomotive motors compact, ventilated, cooled, protected from internal damage and mechanical injury, and of ample range of adjustment and capacity to permit of continuous operation at varying or full speed or power, and to stand an overload of 100 per cent for three minutes and of 50 per cent for one hour, without excessive heating of armature, commutators, or fields above the temperature of the surrounding atmosphere. A thin, tough, and elastic insulation material, unaffected by humidity or a temperature of 400 deg. F., and having the requisite dielectric strength.

10. A development of the maximum locomotive power for rapid acceleration and regular working, requiring no transition, as from series to multiple, in the transmission of the current to the motors, and providing for a uniform increase or decrease in tractive power to prevent irregular drawbar stresses.

11. Suitable pumps to provide compressed air for the locomotive power brake, track sander, bell and signal operation, together with steam train heating device, and the other usual equipment.

12. Automatic positive devices on the locomotive to insure protection in event of accidental short circuit, or disablement of the engineer.

13. An arrangement on the locomotive which will automatically provide for electrical braking and return to the line for the use of pulling locomotives a considerable percentage of the energy that is generated by trains descending grades, or stopping, and which energy is ordinarily wasted in destroying material and equipment by brake shoe action on wheels or rails.

14. A high potential current producing, and an aerial conveying system, reasonable in first cost and economical for maintenance; the generation of the electrical energy at a fireproof central plant for the least cost per kilowatt hour; the transmission of the lowest current over the minimum amount of metal contained in overhead contact lines, protected for weather, voltage, and lightning conditions, and insuring continuous operation in event of line or equipment failure or accident; the conservative use of battery as storage for extra power that can be generated at small cost during light load and utilized to good advantage in the event of breakdown or during intermittent and peak loads; the least number of transformer or converter stations; the minimum feeder, conversion, and resistance losses in current, and the elimination of electrolytic action.

FREIGHT HELPER STEAM LOCOMOTIVES.

Steam locomotive No. 2400, which is of the Mallet articulated duplex compound type, was designed jointly by the builders and the railroad, and the construction was completed in April, 1904, after which it was exhibited at the Louisiana Purchase Exposition.

After the closing of that exhibition the locomotive was brought to the Connellsville division and put into regular service on January 6th, 1905.

For the purpose of increasing the capacity of an eastbound track, balancing of the power on the division, and to reduce the number of locomotives and crews required to handle heavy freight tonnage over a busy mountainous district, it was necessary to produce a locomotive with maximum adhesion for tractive and braking power, a minimum rail pressure per driving wheel, and a short rigid, combined with a long flexible, driving wheel base, to adapt it to a mountain line having considerable curvature and gradient. To accomplish this it became necessary to Americanize foreign railroad practice by making use of the Mallet articulated feature, which permits of the use of a maximum effective wheel base, with a materially reduced rigid wheel base, and provides for a helper locomotive that can develop an average through freight train speed without excessive wear. The subdividing of the power through the use of four independent cylinders, pistons, main rods, crank pins, and frames, in place of two, and the better balancing of the reciprocating parts, result in less strain on all parts, and reduce the liability for breakage and failure.

While the wearing and total parts per locomotive are increased, they are greatly reduced when compared with the development of the same power by tandem locomotives, and the reduction in concentrated stresses and weight insures a more satisfactory and economical maintenance of those details most susceptible to depreciation.

To reduce the water and fuel consumption and relieve the boiler of unnecessary punishment, the duplex Mellin system of compounding was introduced, with an arrangement of independent high and low pressure cylinders, equipped with inside admission piston and double ported flat valves, respectively, providing for a uniform and maximum tractive effort, large receiver capacity and accessibility for inspection and maintenance.

The application of a valve motion to give good steam distribution; maintain permanence of adjustment; overcome the disadvantages of extreme reciprocating, revolving and suspended weight, wear, and liability for failure, as in the modern development of the Stephenson eccentric driven link gear, provide opportunity for substantial bracing of the main frames, and to give accessibility to driving axle bearings, and reduction of motion gear parts and bearings with arrangement in the same vertical plane, accessible for inspection, lubrication, cleaning, and maintenance, was given careful thought, with successful results, through the application of the Walschaert gear. The use of this motion also provides a location for the brake cylinders, by which means the brake shoes can be applied to the forward moving side of the driving wheels, which insures more uniform braking action and relieves the running and brake gear and frames of excessive reverse stresses and vibration during the use of brakes.

All direct pressure steam pipes are outside, and are rigidly connected between the boiler and cylinders, and the flexible pipes being only made use of to convey the receiver and exhaust low pressures have provided for a design and construction that will insure against such leakage of any of these joints as would make their use undesirable. The removal of all but the exhaust pipe from the smoke-box eliminates the objectionable steam pipe arrangement between the boiler and cylinders, which is generally followed out in American locomotive design.

The total weight of 334,500 pounds for the engine in working order is all carried on the driving wheels, which are 57 inches in diameter. Including the tender, which has a capacity of 16 tons of coal and 7,000 gallons of water, the total weight is 479,500 pounds, or about 193,500 pounds less than the combined weight of two of the consolidation locomotives that are used for through freight service over this same mountain district.

While the draw bar pull behind the tender of two of the consolidation locomotives is about 79,400 pounds, the draw bar pull of No. 2400 is about 74,000 when working compound, and 84,000 pounds when working simple. The weight of train that can be taken up the mountain by two of the consolidation locomotives is about 2,025 tons contained in loaded steel cars of 100,000 pounds capacity. The weight of train that No. 2400 and one of the consolidation locomotives can take up the grade is about 3,210 tons, contained in similar cars. The above figures are based on the locomotives operating at a speed of 10 miles per hour under fair coal and weather conditions, and with No. 2400 working in compound gear.

The total elevation from Connellsville to Rockwood is 931 feet, the ruling grade between Confluence and Fort Hill being one per cent, and the total distance 43.4 miles.

In through freight service, from Connellsville to Rockwood, No. 2400, singly, has moved, in 36 steel cars, 1,668 tons of lading, and 702 tons of cars, or a total of 2370 tons in the cars. Adding the weight in working order of the locomotive and averaging the weight of the tender loaded with coal and water at 225 tons, it would make the total weight of the train, including locomotive and tender, 2,594 tons, about 64.3 per cent of which was paying load.

The actual running time was four hours, making an average speed of 10½ miles per hour. When handling this tonnage over the hardest pulls and around 8 deg. 30 min. curvature, as high a rate of speed was maintained as with through freight trains of 1,200 tons total, when handled by consolidation locomotives.

Had this same train of cars been hauled by the standard consolidation type locomotive, it would have required the maximum hauling capacity of two locomotives to have handled it at the same rate of speed, and the average weight of the motive power would have been 304 tons, making the total tonnage of the train 2,674 tons, and about 62.4 per cent of which would have been paying load.

When helping trains consisting of consolidation type pulling locomotive having a tractive power of 39,700 pounds, with 40 cars consisting of about 2,400 tons, weight of lading and cars, No. 2400 has pushed 36 of the 40 cars in the train on 3 and 4 degrees curvature, and 1 per cent grade, making an average speed of about 4½ miles per hour, and has pushed the entire train and pulling locomotive, weighing about 2,550 tons, when the pulling locomotive was shut off, at a speed of two miles per hour and maintained the working steam pressure and the normal water level for a distance of one-half mile on the same curvature and grade, and which performance could have been continued.

The performance of this locomotive for the one year period, January 6th, 1905, to January 5th, 1906, both inclusive, is as follows:

Total locomotive mileage (computed on basis of six miles per hour when locomotive is in helper service, and straight mileage allowed when locomotive is handling through freight trains)	44,976
Miles run per ton of 2,000 pounds run-of-mine, 20 to 40 per cent volatile bituminous coal used	9.26
Gallons of water used per 100 miles run	15,207
Pounds of water used per pound of coal consumed, at temperature of feed water	5.870
Miles run per gallon of engine oil	145
Miles run per gallon of valve oil	200
Miles run per pound of crank pin grease	294
Miles run per ton of sand used	485
Cost of labor and material for running repairs per 100 miles run	$3.16
Cost of labor and material for general shop repairs per 100 miles run	$2.41

The average total operating and maintenance expenses during the year for fuel, water, labor and material for the locomotive repairs, engineer's and fireman's wages, wiping, hostlering, washing boiler, inspecting and dispatching, lubrication and miscellaneous supplies, was approximately $26.90 per 100 miles run. To this figure can be added an allowance on account of mileage credited but not actually run, difference in cost of fuel delivered at power plant and on locomotive tender, and for the maintenance of fuel and water supply plants, and there will still be a large margin in favor of the steam as compared with electric locomotive performance, under fairly similar conditions.

The actual miles run during a twenty-four hour period by this locomotive when available for the Transportation Department use varied from a minimum of 88 miles to a maximum of 154 miles, depending upon the train movement.

During this period the locomotive was used for pushing freight trains up mountain grades between Rockwood, Pa., and Sand Patch, Pa., a distance of 16½ miles, and for hauling through freight trains between Connellsville and Rockwood, a distance of 43.4 miles.

During the last five months of its year's service, August 7, 1905, to January 6, 1906, both inclusive, the locomotive was out of service 11 days, on which no mileage was made on account of boiler washing, staybolt tests, repairs, etc., due to ordinary wear and tear, or about 6 per cent of its time unavailable for transportation department work.

At Rockwood, the station out of which the locomotive operates when it is in helper service, there have been no facilities, except an ash pit to enable the cleaning or drawing of fires, and a water service which permits the rinsing out or filling up of the boiler. The locomotive remains in service out of this point for a two or more weeks' period, and is then taken to Connellsville for washout, staybolt test and the necessary inspection and running repair work.

Allowing for firebox and boiler tube renewals, heavy machinery repairs, etc., we estimate, from the last year's performance, that at the end of ten years the shop charges for working repairs will have averaged not to exceed 9 cents per mile run.

When operating over combination level and mountain divisions, No. 2400 will consume less coal per ton per mile than the various types of simple consolidation locomotives now in the service, and when operated on a comparatively level line it consumed materially less coal per ton mile. On the mountainous part of the division, the fuel consumption per ton mile is more favorable than for the simple consolidation locomotives, but not to such a great extent as when working on the more level portions of the division.

(To be continued.)

THE DEVELOPMENT OF THE SUEZ CANAL

BECAUSE of the rapid progress in the increase of the dimensions and tonnage of modern steamships, extensive widening operations and developments in the docking and wharfing facilities of the Suez Canal are being effected. The navigable dimensions of the waterway are now nearly double what they were twenty years ago, the superficies of the vertical profile having been increased from 320 to 580 square meters in the ordinary channel and to 740 square meters in the numerous crossing places or gares. From 1898 to 1904, owing to the increasing dimensions of vessels, twenty larger gares were carried out at intervals of three miles, each having an effective length of 2,640 feet, with approaches at either end of 984 feet. At each gare the width at the bottom of the canal is 150 feet and at the water level over 300 feet, the depth of the gare itself being 93 feet. Taken as a whole, the width on the water level of the canal in the northern half varies from 300 to 360 feet, and in the southern half from 240 to 300 feet. In 1902 the maximum draft was increased from 25 feet 6 inches to 27 feet on January 1 of this year.

The tariff when the canal was opened was two dollars per ton for laden vessels, but this rate has now been reduced to $1.55 per ton, the tariff for passengers remaining at the original figure of two dollars. The mean net tonnage has increased from 1,900 tons in 1871 to 3,191 tons in 1905. Out of a total number of 4,116 vessels passing through the canal in the year

1905, 2,484 were British, representing a total tonnage of 8,556,940 tons net, a decrease of 195 vessels and 476,989 tons respectively upon the previous year, and representing a British percentage in vessels of 60.4 per cent and in tonnage 63.6 per cent. These figures, however, apply only to the general total, the British percentages in regard to merchant vessels only having risen during the past five years from 67 to 74 per cent in number and from 71 to 77 per cent in net tonnage. The speed of transit remains at the same time—18 hours—but the general effective rate for mail steamers is 15 hours.

THE MODERN MANUFACTURE OF ALCOHOL.*

ALCOHOL is composed of carbon, hydrogen, and oxygen, combined in invariable proportions. Chemistry has not yet discovered a method of making alcohol

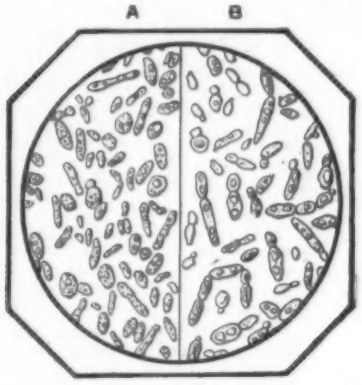


FIG. 1.—SACCHAROMYCES CEREVISIÆ, OR BREWERS' YEAST. MAGNIFIED 400 DIAMETERS.

directly from its elements, although more complex substances can be thus formed by direct synthesis. Water (H_2O) and carbon dioxide (CO_2) may be produced by the direct combination of hydrogen and carbon, respectively, with oxygen; that is, by burning hydrogen and carbon in the air. Now certain carbohydrates, the sugars, of which the general formula is $(CH_2O)^n$ are produced when an electric current is passed through water charged with carbon dioxide (soda water).

Some day, no doubt, alcohol will be made by direct synthesis. It can now be made by an indirect synthesis from calcium carbide or barium carbide, the raw materials of the whole process being lime or baryta, charcoal, sulphuric acid, and certain reducing or deoxidizing agents. The process comprises five parts. First, the carbide is made by heating to 3,600 deg. F. in the electric furnace a mixture of charcoal, coke, or coal (carbon) with lime (calcium oxide), chalk (calcium carbonate), or the oxide or carbonate of barium. The carbon combines with both the oxygen and the metal of the lime or baryta, forming carbon mon-

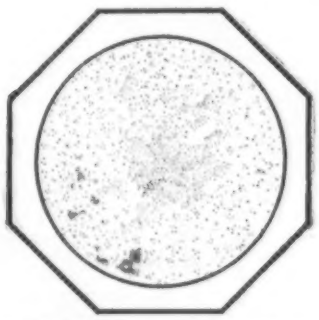


FIG. 2.—MYCODERMA ACETI, THE FERMENT THAT PRODUCES VINEGAR

oxide and calcium or barium carbide, as indicated by the following equation:

$$\underset{\text{(calcium oxide)}}{CaO} + \underset{\text{(carbon)}}{3C} = \underset{\text{(carbon monoxide)}}{CO} + \underset{\text{(calcium carbide)}}{CaC_2}$$

In the second stage of the process acetylene is produced by mixing the carbide with water, thus:

$$\underset{\text{(calcium carbide)}}{CaC_2} + \underset{\text{(water)}}{2(H_2O)} = \underset{\text{(calcium hydroxide)}}{CaH_2O_2} + \underset{\text{(acetylene)}}{C_2H_2}$$

The calcium unites with water to form a hydroxide (slaked lime), liberating hydrogen which combines with the carbon to form acetylene. A similar reaction occurs with barium carbide, which is to be preferred to calcium carbide because the barium hydroxide produced is valuable, while slaked lime is almost worthless. Lime is made cheaply by calcining limestone or calcium carbonate, but the more valuable barium oxide and hydroxide are not so easily obtained from the natural carbonate. The third stage of the synthesis of alcohol consists in the conversion of acetylene into ethylene by heating it with hydrogen or treating it with reducing agents, thus:

$$\underset{\text{(acetylene)}}{C_2H_2} + \underset{\text{(hydrogen)}}{H_2} = \underset{\text{(ethylene)}}{C_2H_4}$$

In the fourth stage ethyl sulphuric or sulphovinic acid is formed by prolonged and energetic agitation of ethylene with strong sulphuric acid, which gradually absorbs 120 times its own volume of ethylene gas. The reaction is as follows:

$$\underset{\text{(ethylene)}}{C_2H_4} + \underset{\text{(sulphuric acid)}}{H_2SO_4} = \underset{\text{(ethyl sulphuric acid)}}{C_2H_5SO_4}$$

In the fifth stage the ethyl sulphuric acid, diluted with ten times its bulk of water, is decomposed by boiling into sulphuric acid and alcohol, thus:

$$\underset{\text{(ethyl sulphuric acid)}}{C_2H_5SO_4} + \underset{\text{(water)}}{H_2O} = \underset{\text{(sulphuric acid)}}{H_2SO_4} + \underset{\text{(alcohol)}}{C_2H_6O}$$

The alcohol is distilled off and the sulphuric acid is re-concentrated and used over again.

The manufacture of alcohol by this process is quite possible, but not yet commercially practicable, as it is much more costly than the production of alcohol by fermentation.

The methods actually employed for the commercial production of alcohol are based upon the susceptibility of various vegetable substances to the transformation called alcoholic fermentation. The common saying that alcohol can be made from anything is an exaggeration, but it can be made from many things (paper, rags, potatoes, etc.), which do not seem to have anything in common with it.

The process may be divided into three parts: the production of fermentable matter (fruits, beets, sugar cane, potatoes, grains), the production of alcohol from this matter by fermentation, and the separation of this alcohol by distillation and rectification. The first part belongs to the farm, the second and third, in general, to the factory. The farmer may, however, ferment his fruit juices and sell them in the form of wine and cider. He may even ferment and roughly distill his sugar beets, selling to the distiller and rectifier the crude spirit thus obtained and feeding the unfermentable residue to cattle and swine.

Alcohol can be obtained by fermentation from any material which contains sugar or substances which are easily convertible into sugar. Grape sugar or glucose, for example, is separated by the ferment of brewers' yeast into alcohol and carbon dioxide (carbonic acid) according to the following equation:

$$\underset{\text{(glucose)}}{C_6H_{12}O_6} = \underset{\text{(alcohol)}}{(2C_2H_6O)} + \underset{\text{(carbon dioxide)}}{2(CO_2)}$$

In addition to these two essential products of fermentation, small and variable quantities of glycerine, succinic acid, cellulose, and fatty substances are also produced. If the fermenting liquid or the yeast contains

FIG. 3.—AMYLOMYCES ROUXII. MAGNIFIED 500 DIAMETERS.

impurities, or the fermentation is not properly conducted, amyl alcohol, propyl alcohol, and various acids, ethers, and aldehydes are also formed which contaminate the spirit and necessitate complicated and expensive rectifying and refining processes. According to the equation given above, which takes no account of impurities and secondary fermentations, 100 parts by weight of glucose should be simply divided into 51 parts of absolute alcohol and 49 parts of carbonic acid. In practice, however, about 6 parts of other substances are formed, the principal being glycerine 3.4 parts, succinic acid 0.6 part, fats and cellulose 1.0 to 1.5 parts. The fats and cellulose unite with the yeast and furnish material for its growth.

The substances which are available for the production of alcohol belong to the group known as carbohydrates, of which the general empirical formula is $C^m(H_2O)^n$. They may be regarded as hydrates of carbon, as the molecule contains the elements of a certain number of molecules of water combined with the same or a different number of atoms of carbon. In the former case we have the glucoses, including dextrose or grain sugar, levulose or fruit sugar, and inverted sugar, which is a mixture of dextrose and levulose. All the glucoses have the empirical formula $C_6H_{12}O_6$ and all yield alcohol promptly on the addition of a suitable ferment. The other carbohydrates yield

FIG. 4.—MUCOR BETA.

alcohol only by being converted into glucose either in the course of fermentation or before fermentation. They are divided into two classes. The first class includes sucrose or cane sugar, furnished by the sugar cane, the sugar beet and a few other plants, lactose or milk sugar, and maltose or malt sugar. The sugars of this class have the empirical formula $C_nH_{2n}O_n$, the molecule representing two molecules of glucose minus one molecule of water. Under the influence of a ferment (brewers' yeast) they take up the lacking molecule of water and become converted into glucose (invert sugar) which then ferments in the ordinary manner. The transformation may be written:

$$\underset{\text{(sucrose or cane sugar)}}{C_{12}H_{22}O_{11}} + \underset{\text{(water)}}{H_2O} = \underset{\text{(dextrose)}}{C_6H_{12}O_6} + \underset{\text{(levulose)}}{C_6H_{12}O_6}$$

The carbohydrates of the third and last class, including starch, dextrine, and cellulose, or woody fiber, contain still less of the elements of water, their general empirical formula being $(C_6H_{10}O_5)^n$. They are not directly fermentable nor are they converted into glucose by ordinary yeast. The conversion, which may be effected by dilute acids or by the soluble ferments known as zymases, must be accomplished before the yeast is added. The reaction may be written:

$$\underset{\text{(starch)}}{C_6H_{10}O_5} + \underset{\text{(water)}}{H_2O} = \underset{\text{(glucose)}}{C_6H_{12}O_6}$$

In view of the close chemical relationship of the three classes of carbohydrates, it is not surprising to find one class converted into another in the living plant. The glucoses appear to be produced first by the mysterious agency of chlorophyl, the green coloring matter of leaves, and to be subsequently transformed into cane sugar, starch, and cellulose, by loss of the elements of water.

Thus in sugar beets harvested at the end of the first season of growth, most of the glucose has become converted into sucrose (cane or beet sugar) which is accumulated in the roots, but if the plants are allowed

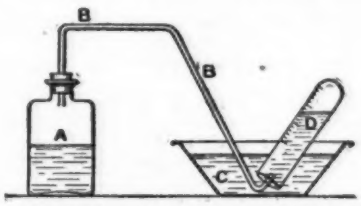


FIG. 5.—AN EXPERIMENT IN FERMENTATION.

to grow another year this store of sugar passes into the stalks and seeds, where it undergoes further transformation into cellulose and starch.

In the manufacture of alcohol from grain and from beets, these natural changes are artificially reversed, glucose being formed from starch and from saccharose, respectively. Fruits, on the other hand, contain glucose ready for fermentation and consequently form the earliest known and most readily available source of alcohol.

Ferments and Fermentation.—The alcoholic ferment of ordinary yeast is a minute living organism which assimilates food, eliminates waste products, grows, and multiplies. It is sensitive to heat and cold and even susceptible to disease, though it is remarkably tenacious of life. Duclaux revived yeast that had lain dormant five years.

Yeast commonly appears as a soft gray or brown paste with a faint characteristic odor. When examined with the microscope it is seen to be composed of a multitude of separate globules of liquid protoplasm, each enveloped by a tough cell-wall and containing solid granules which, according to some observers, move rapidly to and fro. Dumas has computed the number of cells in a cubic millimeter of yeast as 2,772,000 and the number in a surface area of a square millimeter as 19,800 (about 3,500 in a linear inch, 12 millions in a square inch, 43 thousand millions in a cubic inch). Three thousand yeast cells, free from water, weigh less than one Troy grain. According to

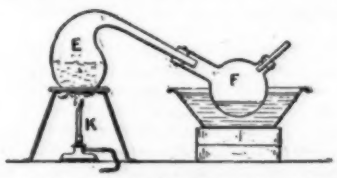


FIG. 6.—DISTILLATION WITH RETORT AND RECEIVER.

Brunet, yeast is a vegetable organism and contains nitrogen. It multiplies both by budding, in which a new cell sprouts from an old one, and by the development of granules which, liberated by the bursting of the mother cell, become the nuclei of new cells. It multiplies slowly even when deprived of nutriment and very rapidly in presence of sugar.

There are distinct breeds of yeast which have acquired by artificial selection an immunity to poisons which destroy ordinary yeast. The employment of these "thoroughbred" ferments enables the manufacturer to destroy injurious ferments or germs with antiseptics without injuring the alcoholic ferment which alone is useful to him. Ferments are of many kinds and they are indispensable in various industries—brewing, baking, the manufactures of wine, vinegar, cheese, etc.

Fermentation may be defined as a chemical change produced in an organic compound under the influence of another organic body, the ferment. Usually the products of the reaction are derived entirely from the substance undergoing fermentation and owe none of their substance to the ferment itself. Consequently, a large quantity of material can be decomposed or transformed by an infinitesimal amount of the ferment.

The products of fermentation vary with the nature of both the ferment and the substance fermented. Each kind of fermentation is generally designated by the

* Specially translated from "Sa Majesté l'Alcool," by L. Baudry de Saunier, for the SCIENTIFIC AMERICAN SUPPLEMENT.

name of one of its principal products. For example, the decomposition of sugar into alcohol and carbonic acid, by the agency of ordinary yeast, is known as the alcoholic or vinous fermentation. Alcohol itself, in presence of another ferment, *Mycoderma aceti*, undergoes the acetous fermentation in which it becomes converted into acetic acid, or vinegar. There are also lactic and ammoniacal fermentations, etc., each caused by a special ferment.

Here we have to do only with ferments capable of causing alcoholic fermentation. They are of two kinds: organized ferments and amorphous ferments. Organized ferments are unicellular living organisms (each cell constituting a complete individual of microscopic size) which grow at the expense of the matter undergoing fermentation. They are killed or, at least, more or less paralyzed by the poisons called antiseptics (for-

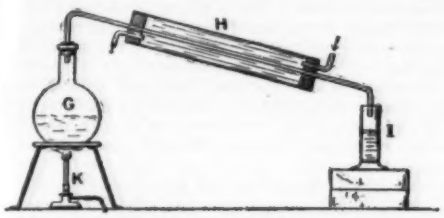


FIG. 7.—DISTILLATION WITH LIEBIG'S CONDENSER.

mol, carbolic acid, etc.) unless they have been made immune by culture and selection.

The organized ferments that cause vinous fermentation form the group of saccharomycetes or true yeasts. Their cells are egg-shaped, multiply by budding and flourish and produce alcohol most energetically when they are disseminated throughout the solution of sugar, instead of being merely scattered over its surface, exposed to the air. There are several species. *Saccharomyces cerevisiæ*, the ferment of brewers' yeast, includes two sub-species or varieties: the "low" ferment of German beer which works at the bottom of the vat, at a temperature of 43 deg. to 50 deg. F., at which most other yeasts are inert, and the "high" ferment of English and French beer or ale, which works at the top of the vat, at from 61 deg. to 68 deg. F. Fig. 1 shows the cells of low yeast magnified 400 diameters, *A* representing old and *B* young yeast. The cells of high yeast are rather larger and rounder.

Saccharomyces ellipsoidus is the ferment of wine. It occurs on the skins of grapes which, consequently, ferment spontaneously when crushed. Several other species occur in different fruits and cause their fermentation. *Saccharomyces minor* is the ferment of leaven and bakers' yeast. It is notable for its slowness of action.

Pasteur has made a distinction between "aerobic" and "anaerobic" ferments, the former living in contact with air and the latter living without air. Of the yeasts mentioned above some are aerobic, some are anaerobic and others may live either with or without air, producing different effects in the two cases.

For example, brewers' yeast growing on the surface of a saccharine liquid multiplies very rapidly and for that very reason produces little alcohol but completely oxidizes the sugar into carbonic acid and water. The anaerobic yeast buried deep in the liquid, on the other hand, grows and multiplies less energetically, but produces more alcohol. Such, at least, is the theoretical view of the matter. The presence of air in excess causes an active, tumultuous fermentation which yields little alcohol. But, in fact, the process is largely self-regulating. The layer of carbonic acid evolved by the rapid surface fermentation acts as a screen and impedes further access of air and the uppermost layer of the fermenting liquid affords similar partial protection to the stratum directly beneath it. On the other hand,

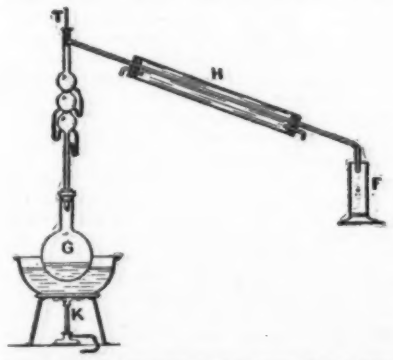


FIG. 8.—EXPERIMENTAL RECTIFYING APPARATUS.

the continual agitation of the entire mass of liquid by escaping bubbles of carbonic acid assures sufficient aeration to maintain the activity of the yeast throughout. Hence the yield of alcohol per pound of sugar decomposed remains normal, none being wasted in excessive growth of the yeast itself.

Amorphous Ferments.—Amorphous or soluble ferments are not living organisms, but lifeless chemical compounds secreted by such organisms. They are not affected by antiseptics, do not propagate themselves and are consumed in proportion to the quantity of fermenting substance decomposed by them. None of these peculiar compounds has yet been made synthetically. They are very numerous and are known as diastases, zymases, or enzymes.

One variety is the amylase of malt, or sprouted barley, which converts the starchy constituents of grain, potatoes, etc., into fermentable sugar.

Another variety is sucrase (called also invertine, intervertine, zythozymase, glucosic ferment) which "inverts" cane sugar, forming fermentable invert-sugar. Other varieties are maltase, inulase, etc. Among zymases of animal origin are the ptyaline of saliva, the pepsine of the gastric juice and pancreatine secreted by the pancreas.

The change produced by zymases in carbohydrates consists in hydration, or addition of the elements of water. Dilute sulphuric acid has a similar effect but the soluble ferments present the advantage that a very small quantity of the ferment suffices to effect the result. A small quantity of amylase, for example, will convert many pounds of starch into glucose.

Fermentation Caused by Molds.—The useful properties of yeasts and zymases are found united in the microscopic fungi known as molds. Under the microscope mold appears as a mass of elongated and interlaced filaments to which the name mycelium is given. The reproductive spores are borne on the ends of short branches distributed along the filaments.

These molds, in the process of life and growth, convert cane sugar, starch, and other carbohydrates into fermentable sugar, or glucose, and also decompose the latter into alcohol and carbonic acid. To produce these effects the molds must be "anaerobic," or secluded from the air. In their "aerobic" condition at the surface of the liquid they act too energetically and completely oxidize the carbohydrates into carbonic acid and water. The maker of alcohol, therefore, has three classes of useful ferments at his disposal—the alcohol makers or yeasts, the glucose makers or zymases, and the molds which make both glucose and alcohol—and he employs one class or another according to circumstances.

Experimental Production of Alcohol by Fermentation.—The process of vinous fermentation may be illustrated by a simple experiment. The flask *A* (Fig. 5) is half filled with a 10 per cent solution of glucose to which is added a small quantity of yeast stirred in several times its volume of water. The temperature of the liquid should be 75 or 80 deg. F. Bubbles of gas soon begin to rise and displace the water in the jar, *D*. It is easy to prove that this gas is carbonic acid by filling *D* with lime-water. A cloud of insoluble carbonate of lime soon makes the liquid turbid, but as the evolution of gas continues, the cloud disappears owing to its conversion into soluble bicarbonate of lime. The fermentation continues several hours. When it has ceased the presence of alcohol in the bottle *A* can be detected by its odor. It is impossible to obtain strong spirit by fermentation alone because the fermentation is arrested by the antiseptic properties of the alcohol produced.

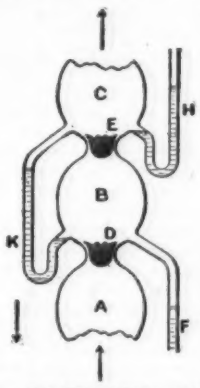


FIG. 9.—RECTIFYING BULBS.

If cane sugar or beet sugar is substituted for glucose in this experiment the final result will be the same but the fermentation will be slower because time is required for the sugar to be converted into fermentable invert-sugar. If it is desired to make alcohol by fermentation from potatoes or other starchy materials the starch must first be changed into glucose by the action of zymases or of dilute acids. Finally, we can make alcohol from rags or scraps of paper by mixing them, in a glass or porcelain vessel, with an equal weight of strong sulphuric acid which gradually converts them into a dark brown gummy mass in which all the cellulose has become transformed into dextrine. The dextrine must next be converted into glucose by boiling the mass for several hours with 10 to 20 times its weight of water. The sulphuric acid is then precipitated in the form of calcium sulphate by the addition of chalk and the clear syrup is poured off and fermented with yeast.

Experiments in Distillation.—Two types of experimental distilling apparatus are shown in Figs. 6 and 7. The former consists of a retort, *E*, heated by a Bunsen burner and a receiver, *F*, cooled by partial immersion in cold water. In the second apparatus the products of distillation are condensed before they reach the receiver by passing through a long narrow tube surrounded by a wide tube through which a stream of cold water flows, as indicated. This arrangement is called a Liebig's condenser. The fermented liquid produced in the previous experiment is heated in the retort *E* or the flask *G* (very gently at first to prevent foaming and overflowing due to the dissolved carbonic acid gas). Soon the liquid begins to boil and evolve mixed vapors of alcohol and water which are condensed in the receiver, *F* or *I*. As alcohol is more volatile than water all of the alcohol will be distilled and collected in the receiver when about one-third of the water has passed over. For the same reason the first portion of the distilled spirit is the strongest in alcohol. The final result of the operation is a weak spirit which may be made stronger by redistilling it, stopping the process each time when a third of the liquid has passed over.

Such redistillations were practised by eighteenth

FIG. 10.—LE BEL AND HENNINGER APPARATUS.

century distillers before the introduction of the method of combined distillation and rectification devised in 1900 by Eduard Adam.

Experiments in Simultaneous Distillation and Rectification.—Adams's method combines a fractional condensation of the mixed vapors with a process of washing them by means of the portion already condensed. The laboratory apparatus of Le Bel and Henninger, illustrated in Figs. 8 and 9, is suitable for experimental use. It consists of a series of glass bulbs, connected by long bent tubes and also by wide mouths, partly stopped by baskets of wire gauze. These baskets allow the vapors from the flask below to pass upward but arrest the downward flow of the liquid condensed on the walls of the bulbs so that in each bulb the ascending vapor is compelled to bubble through a layer of liquid. The depth of this layer is determined by the bent tube communicating with the bulb below and these tubes assure a regular return flow of the condensed liquid to the distilling flask. Three bulbs, connected with a Liebig's condenser, produce strong spirit in a single distillation. The bulbs may be replaced by the simpler rectifying apparatus shown in Fig. 11. This is a vertical tube about a foot long and two inches wide, nearly filled with glass beads, broken glass or pieces of wire gauze which furnish ample condensing surface and opportunity for intimate contact of liquid and vapor.

These simple experiments will serve to illustrate and explain the practical apparatus and methods described hereafter.

(To be continued.)

RECENT ELECTRICAL DEVELOPMENTS.*

RESISTANCE FURNACES.

THE only electric furnace process which has been introduced into practice on a commercial scale for the production of high-grade zinc is that of De Laval in Sweden, who uses an arc furnace. The criticism has, however, sometimes been made that an arc furnace does not exactly fulfill all requirements in zinc metallurgy, for the main reason that for zinc production not such a high temperature is required as is generated by the electric arc, and that it is rather more important to have the temperature under easy and absolute control. This may be more easily accomplished with a resistance furnace. Mr. W. McA. Johnson, who is known to have made extended ex-

FIG. 11.—RECTIFICATION BY GLASS BEADS.

periments some years ago on electric zinc reduction for a western zinc company, has recently patented a resistance furnace for the reduction of zinc ores and the distillation of the metal. It is in the form of an inclined, air-tight, rotating drum, composed of several independent and electrically insulated sections. Within the furnace walls longitudinal passages are provided, filled with powdered graphite serving as the heating resistor.

A patent for a simple and compact resistance fur-

* Electrical World.

nace for melting down a charge has recently been granted to Mr. I. L. Roberts. The outer iron casing is lined with a mixture of ground asbestos and magnesium carbonate, well packed in place to provide good heat insulation. Inside of this is a chamber of firebrick within which is placed the iron crucible containing the charge. But between the walls of the firebrick chamber and the iron crucible, granulated or powdered coke, mixed or not with silica, etc., is provided to act as the heating resistor. Furnaces of this general type with a granulated resistor have already been used on a large scale by Mr. E. G. Acheson; a type of furnace with the crucible imbedded in a granulated resistor has recently been studied in detail by Mr. F. A. J. Fitz Gerald; Girod has proposed such furnaces for steel refining; a granulated resistor material with the trade name of kryptol is now quite extensively used for laboratory purposes. The chief reason why this general type of furnace attracts so much attention lies in the fact that it permits a very easy regulation of temperature.

INDUCTIVE FURNACE.

The electric induction furnace was first tried independently by various experimenters in this country some sixteen years ago. Mr. A. E. Colby took out the fundamental patents in 1890. Direct commercial developments, however, did not result from this early work. The credit for having made the induction furnace a successful commercial instrument in steel metallurgy is due to Kjellin in Sweden. The subject is just now attracting much attention in this country, and only a few weeks ago the first induction furnace, designed by Colby, was given over to commercial practice for steel making at the Tacony works of Henry Disston & Sons, near Philadelphia. The designs of Colby and Kjellin are essentially the same. In each the crucible containing the charge is in the form of a horizontal ring, acting as the single secondary turn of the transformer which represents the furnace. This would, indeed, appear to be the most natural arrangement. The charge, representing the secondary of the transformer, is homogeneous. Recently, however, Mr. T. F. Snyder has patented a peculiar modification, the secondary being arranged in his case in a vertical plane. It is no longer homogeneous, but is composed of conducting materials of different specific gravity. Copper bars are at the bottom; above them rests the molten metal, above which there is the light slag. With this arrangement it is possible to produce different temperatures at different points of the secondary, and the inventor points out that he can produce the maximum heating effect at the top; that is, in the slag upon which the ore to be melted is fed.

FERRO-ALLOYS.

The chief technical difficulty of production of ferro-alloys in the electric furnace is to make them with a low contact of carbon. Mr. E. F. Price proposes in a recent patent to use low-carbon ferro-silicon as the reducing agent for the production of other ferro-alloys, like ferro-chrome, low in carbon. His process, therefore, consists of ten steps. The first is the production of ferro-silicon, high in silicon and low in carbon, which is commercially feasible. The ferro-silicon thus produced is comminuted and mixed with chromite and lime and treated in an arc furnace for the production of ferro-chrome. It might be feasible to modify this process by making metallic silicon in the first stage and use this as a reducing agent later on.

CALCIUM CARBIDE.

Three patents, recently granted, refer to the manufacture of calcium carbide. Mr. E. F. Price, of the Union Carbide Company, proposes to draw the waste carbon monoxide from the electric furnace and burn it in a preheating chamber through which the finely divided mixture of lime and coke is showered before being fed into the electric furnace. Mr. J. M. Morehead, who is also an engineer of the Union Carbide Company, patents a modification of the well-known Horry type of furnace. The essential feature is that a region of reduction is established under a gas-tight hood, the charge being fed into and downward within the hood into the region of reduction. The hood is sealed by a layer of the charge material extending below the lower end of the hood, and the waste gases are withdrawn from the hood.

Mr. J. E. Hewes endeavors to render the process of carbide production perfectly continuous, by placing trough-shaped hearth plates on an endless traveling chain and moving them below two adjustable electrodes.

MAGNESIUM SULPHATE AS AN ANESTHETIC.

IT has recently been determined by Meltzer that certain magnesium salts when injected subcutaneously or directly into the circulation, or when applied to the nerve trunks or spinal cord, inhibit nerve impulses and seem to manifest a selective action for nerve tissues. Death in the experimental animals, moreover, was found to be due in all cases to paralysis of respiration alone, no depressing action on the heart being observed. Encouraged by the striking and apparently harmless effect on the lower animals, Meltzer was led to recommend the use of this agent in the production of anesthesia for surgical operations on human beings and it has thus far been employed in twelve cases by Haubold, Willy Meyer, and Blake. The latter makes a general report of the results obtained which affords some basis for judging the value of the method. The dose employed in nearly all cases corresponded with one cubic centimeter of a 25 per cent solution of magnesium sulphate to every twenty to twenty-five pounds of body weight. The operations included appendectomy, curettage, perineorrhaphy, hernia, abscess incision, fistula in ano, and the reduction of a Potts' fracture—quite a miscellaneous array. In a few cases a small amount of chloroform was given as an adjuvant. The anesthesia induced by the method was characterized by considerable variability, and in two instances no anesthetic effect was noted, both these patients being alcoholics. The motor symptoms were the most constant, and varied from a slight weakness of the muscles of the lower extremities to a complete paralysis of the latter and also those of the trunk and upper extremities. This paralysis persisted, as a rule, longer than the local disturbances of sensation, lasting in some instances almost two days. The reflexes were first diminished, then abolished, and then returned slowly; retention of urine was almost always present. Great variability was also noted in the effect on the mental faculties; total unconsciousness was present in only six cases, and when the patients came out of the resulting coma they were restless and showed unmistakable evidences of mental confusion. The respirations were always markedly inhibited and thus served as an indication of approach to the danger line. Vomiting was present in all the cases in which the magnesium sulphate had produced any marked effects, and sometimes was annoying and persistent.

It is quite apparent that the effects of this drug as an anesthetic are so variable that some hesitancy must govern any recommendation for its general use, even if spinal anesthesia were as desirable as general anesthesia by the usual methods. Blake points out several features in its favor which are not possessed by cocaine, chief among which is the absence of any depressing action on the heart. Its action is also more general, but in the full doses thus required it is difficult to gage the effect, and alarming results may follow. The prolonged action which has been noted may make its use desirable when a prolonged anesthetic effect is needed, such as in the treatment of aneurisms by compression, and its marked effect on the perineum may be of some value in doing a prostatectomy on a patient with bad kidneys and a myocarditis. In view of the associated dangers and uncertainties, however, it is doubtful whether any extended application will ever be accorded to this procedure.

Blake also had an opportunity of studying the effect of magnesium sulphate injections in cases of tetanus, where its use was suggested by the marked inhibition which had been noted on both afferent and efferent nerve impulses. It was given in connection with other antitetanic measures, and in one of the two cases in which it was employed the results were apparently favorable. The other was practically a hopeless case, but even here a marked effect in restraining the convulsions was noted and the pain was relieved. As the spasm of the muscles of mastication and deglutition was lessened, feeding was more easily accomplished. The effect of the substance was continued over considerable periods, from twenty-nine to thirty-seven hours, without any cardiac depression; the repeated injections seemed to have no harmful effect, but a certain degree of tolerance became established. As to what the action of magnesium sulphate may be in tetanus, we are still in the dark. Although it may have some chemical action on the toxins, Blake thinks that its effect is purely symptomatic, and it may therefore be employed with perfect justification as an adjuvant to other treatment, mainly the use of antitoxin.—Medical Record.

METEORITES.*

By OLIVER C. FARRINGTON, Curator of Geology, Field Museum, Chicago.

METEORITES come from meteors. Meteors are large shooting stars. Shooting stars may be seen on almost any clear, moonless night, the number visible to a close observer being usually about four or five an hour. They are liable to appear in almost any quarter of the sky and usually vary in brilliancy and color. In addition to the ordinary shooting stars there are certain periods of the year when much larger numbers are to be seen, producing what are called star showers. Two of the best known and typical of these showers occur early in August and about the 13th of November. These are known as the August and November meteors, or as the Perseids and Leonids, these latter names being given them because the meteors seem to come in the one case from the constellation of Perseus and in the other from that of Leo. This does not mean that they actually originate in those constellations, but simply that they are in the line of sight between us and them. The paths of the falling stars of these showers are, as a whole, parallel, showing that they come from one region of space, but individuals often exhibit curved and zigzag paths. This glancing and deflection of movement is regarded as proof that the substance of the individual meteors is solid. The amount of substance in the individuals is, however, believed to be very small. Calculated from the energy represented by the light which they give forth, it is believed in the majority of cases that the amount of matter constituting the individual meteors would weigh scarcely more than a grain. The individuals of the Perseid showers are yellowish and move with medium velocity; the Leonids are greenish or bluish and move very swiftly, for we meet them head on; while the Andromedes are sluggish in movement and red in color. Recurring, as they do, annually, the shooting stars of these groups are believed to move in elliptical orbits.

Passing apparently by all gradations from the usual shooting stars come the large meteors, known also as bolides or fireballs. These are of much less common occurrence than the shooting stars and naturally attract more attention when they do occur. Their brightness is often such that they can be seen over large areas of country and their passage is often accompanied by loud reports and detonations which are widely observed. From many of them no solid body falls to the earth, but occasionally a stone or iron comes from them. Such are the stones we call meteorites. The phenomena attending the fall of a meteorite are therefore practically those of large meteors. Of such phenomena we have a very graphic account in that of the fall which took place at Homestead, Iowa, at about ten o'clock on the evening of February 12, 1875. The movement of this meteor was north and east, its northward course being 112 miles in length and the eastward one 47 miles. This entire distance was traveled in about ten seconds, so that the velocity of the stones, including their retardation by the air, was at least 15 miles per second. The phenomena are described by C. E. Irish, a civil engineer of Iowa City, as follows: "From the first the light of the meteor could hardly be tolerated by the naked eye turned full upon it. Several observers who were facing south at the first flash, say that upon looking full at the meteor it appeared to them round, and almost motionless in the air, and as bright as the sun. Its light was not steady, but sparkled and quivered like the exaggerated twinklings of a large fixed star, with now and then a vivid flash. To these observers, all of whom stood near the meteor's line of flight, its size seemed gradually to increase, also its motion, until it reached a point almost overhead, or in a direction to the east or west of the zenith, when it seemed to start suddenly, and dart away on its course with lightning-like rapidity.

"The observers who stood near to the line of the meteor's flight were quite overcome with fear, as it seemed to come down upon them with a rapid increase of size and brilliancy, many of them wishing for a place of safety, but not having time to seek one. In this fright animals took part, horses shying, rearing and plunging to get away, and dogs retreating and barking with signs of fear. The meteor gave out marked flashes in its course, one more noticeable than the rest, when it had completed about two-thirds of its visible flight. All observers who stood within twelve miles of the meteor's path say that from the time they first saw it, to its end, the meteor threw down 'coals' and 'sparks.'

"Thin clouds of smoke or vapor followed in the track of the meteor and seemed to overtake it at times, and then were lost. These clouds or masses of smoke gave evidence of a rush of air with great velocity into the space behind the meteoric mass. The vapor would seem to burst out from the body of the meteor like puffs of steam from the funnel of a locomotive, or smoke from a cannon's mouth, and then as suddenly be drawn into the space behind it. The light of the meteor's train was principally white, edged with yellowish green throughout the greater part of its length, but near to the body of the meteor the light had a strong red tinge. The length of the train was variously estimated, but was, probably, about 9 deg., or from seven to twelve miles, as seen from Iowa City. The light about the head of the meteor at the forward part of it, was a bright, deep red, with flashes of green, yellow and other prismatic colors. The deep red blended with and shaded off into the colors of the train at the part following; but the whole head was inclosed in a pear-shaped mass of vivid white light next to the body of the meteor, and the red light fringed the white light on the edges of the figure, and blended with it, on the side presented to the eye.

"From three to five minutes after the meteor had flashed out of sight, observers near the south end of its path heard an intensely loud and crashing explosion, that seemed to come from the point in the sky where they first saw it.

"This deafening explosion was mingled with, and followed by, a rushing, rumbling and crashing sound that seemed to follow up the meteor's path, and at intervals, as it rolled away northward, was varied by the sounds of distinct explosions, the volume of which was much greater than the general roar and rattle of the continuous sounds. This commotion of sounds grew fainter as it continued, until it died away in three to five explosions much fainter than the rest.

"From one and a half to two minutes after the dazzling, terrifying and swiftly moving mass of light had extinguished itself in five sharp flashes, five quickly recurring reports were heard. The volume of sound was so great that the reverberations seemed to shake the earth to its foundations, buildings quaked and rattled, and the furniture that they contained jarred about as if shaken by an earthquake; in fact, many believed that an earthquake was in progress. Quickly succeeding, and in fact blended with the explosions, came hollow bellowings, and rattling sounds, mingled with a clang, and clash and roar, that rolled slowly southward as if a tornado of fearful power was retreating upon the meteor's path."

About 700 pounds of stones were gathered from this meteor. They fell within an elliptical area about seven miles in length and three miles in breadth, the larger ones being at the farther end of the ellipse; as the region is rather thickly inhabited it is somewhat remarkable that no one was hit by one of these stones. If meteorite falls were common occurrences, the danger of being hit by one might be worth considering as a general risk, but they are so rare that no such catastrophe has ever occurred so far as I am aware. The total number of well authenticated instances of

* From School Science and Mathematics.

meteorite falls in all history is only about three hundred and fifty. This is, however, but a small part of the total number which falls to the earth. The ocean covers three-fourths of the surface of the globe and all meteorites falling here are lost. Upon the large uninhabited areas of the earth, too, no record is preserved of meteorites which have fallen. It can be calculated with considerable accuracy that the number of meteorites falling to the earth in a year is about 900, or two to three a day. Yet all that are known number only about 350. Even if we add to these all meteorites found, only about 650 different localities are known. Meteorites therefore are rare objects which must be carefully treasured if we are to learn anything about them.

As regards time of day at which meteorites fall, it is interesting to note that more have been seen to fall in the hours from noon to midnight than in those from midnight to noon. Between noon and midnight 170 falls have been recorded, while between midnight and noon only 87 are known. The majority of meteorites, therefore, it would seem, travel through space with a velocity sufficient to enable them to *overtake* the earth. As to the times of year at which most meteorites fall, it has been found that May and June are the months most favored and October least so. It has been suggested that more are likely to be seen in May and June since more people are out of doors in the summer months, but this argument loses force from the fact that but a small number are seen in July. A noticeable further fact regarding the monthly distribution is that the periods of most abundant meteorite falls are not those of most abundant shooting stars. This appears to indicate that meteorites and shooting stars do not have common origin.

Meteorites may be divided, as regards composition, into three great classes: Stone, iron-stone, and iron. These classes pass into each other by every gradation, but their principal characters are fairly well defined. The stone meteorites are far in excess as regards numbers seen to fall, while the iron meteorites are in excess as regards numbers found. Only nine iron meteorites have been seen to fall, but about 250 have been found. Of stone meteorites 350 have been seen to fall and 40 have been found. It is evident that the reason for the more ready finding of the iron meteorites is that their weight and metallic appearance when struck are likely at attract the attention of an ordinary observer. The stone meteorites on the other hand do not differ notably in appearance from common stones, and hence are likely to be overlooked except in regions where stones do not occur naturally.

In shape and form meteorites exhibit a number of interesting characters. In a large number of cases they may be said to have no definite shape, their forms being irregular and just such as might be produced by breaking a large stone into a number of pieces by a blow of a hammer. This irregular shape is especially wont to characterize the stones of a shower. Other meteorites present more regular forms. Thus one iron meteorite has a flattened cigar shape. It is about three feet in length and weighs 290 pounds. It was found at Babb's Mill, Tennessee. Another meteorite of remarkable form is that known as the ring meteorite, found near Tucson, Arizona. This is an iron meteorite in the form of a complete ring about four feet in diameter and weighing 1,400 pounds. Some have thought this form was due to a rotation of the mass in its descent through the air, by which the air bored a hole through it as an auger bores through wood. It is more probable, however, that such cavities represent a stony or fusible filling which has been pushed or melted out during the descent of the mass. Another form which characterizes several iron meteorites is that of a ramus of the lower jaw of a mammal. This is shown in two iron meteorites, one of which was found in Kokstad, South Africa, and the other in Hex River Mountains, South Africa. The Kokstad meteorite weighs about 80 pounds and the Hex River Mountains about 150 pounds. An explanation given for these jaw-like forms is that they are fragments of what was once a ring like the Tucson meteorite. Again, meteorites may have a shell-like form, indicating that they have scaled off from a larger mass, just as usually happens when a rock is heated and cold water is thrown upon it. Such a form characterizes the Butsura meteorite, which burst into fragments as it fell, but the fragments when put together gave the original form mentioned. The fragments lay at four points, forming a quadrilateral and nearly a mile apart. The breaking of the meteorite must, therefore, have taken place at a considerable height in the atmosphere and the force of the explosion must have been great to have separated them so widely. Another form exhibited by some meteorites is a drop or pear shape. This is shown by two iron meteorites, one of which weighed about nine pounds and fell at Charlotte, North Carolina, August 1, 1835, while the other was found near Boogaldi, New South Wales. It weighed about four pounds. An interesting feature of the Boogaldi meteorite is a series of concentric rings on the larger end showing that the heavy end was foremost in the fall of the meteorite.

Probably the most beautiful and typical form of meteorites and one of which there are many examples, is a conical one. This is exhibited by both stone and iron meteorites. It is shown by the great iron meteorite weighing twelve tons, found in Mexico, and preserved in the museum of the School of Mines of the city of Mexico; also in the stone meteorite from Long Island, Kan., preserved in the Field Museum collection, and weighing about 1,300 pounds. The form of the cone varies somewhat as to flatness, but is never very steep. This conical form is, without doubt, quite largely the result of the motion of the meteorite through the atmosphere and the heat developed thereby. The part of the meteorite in front feels most strongly the heat and friction and is worn away on all sides. While this form is quite largely the result of the heat and friction of the air, however, it is not wholly so, since a meteorite possessing a form which tends to be conical will be turned pointed end foremost by atmospheric resistance when it first strikes the atmosphere. Being in that position the heat and friction tend to preserve this form. Evidences of the different effects of this heat and motion are often beautifully shown upon the different sides of the meteorite. Thus the apex and sides of the cone will be found deeply pitted and thinly crusted, while the base of the cone will be found to be comparatively smooth and to have a thick, glazed crust. The pittings also usually radiate from the apex.

The cause of the heat exhibited during the fall of a meteorite, making itself manifest in the bright light given forth, is not any inherent hotness which the meteorite may possess, but the friction of the atmosphere against the mass. The velocity with which the meteorite moves through space is one of about fifteen or twenty miles per second, and this is slowed down by the atmosphere to one of a few hundred feet per second. The motion of the meteorite is thus converted into heat, and if time were given to conduct the heat into the interior the amount of heat would be sufficient to convert the whole mass into vapor. The motion of the meteorite is, however, too rapid to allow conduction to this extent and the effects of the heat are therefore exerted only on the surface of the meteorite. Instead of being intensely hot when they reach the earth, therefore, meteorites are usually scarcely more than milk warm and sometimes even benumbingly cold. This retardation which the atmosphere produces is, further, a means of protection to us from fatal effects, not only of meteorites but of other falling objects. A raindrop falling from a height of 3,000 feet, about that of the average rain cloud, would strike us with a velocity of 400 feet per second were it not for the atmosphere, but as it is its velocity is reduced to about 30 feet per second. So meteorites on reaching the earth have scarcely a hundredth part of the velocity with which they move through space. Besides retarding the velocity of meteorites the atmosphere exercises another beneficial effect in burning up by its friction a great number of stones of the size of shooting stars and larger which would otherwise subject us to an uncomfortable and perhaps deadly hail.

In size, meteorites vary from minute particles to masses of many tons weight. The largest stone meteorite known is that of Long Island, Kan., preserved in the Field Museum. This stone, when it came into the atmosphere, doubtless weighed about 1,300 pounds, although as found it was broken into several pieces. Among iron meteorites a number are known weighing several tons. Until within the last few years the largest known was one found in the state of Chihuahua, in Mexico. This was a solid mass of iron weighing about 17 tons. This mass was known for several centuries before being taken to the Mexican Museum, where it is now preserved. Another large Mexican meteorite is that of San Gregorio. This weighs about 12 tons. It has likewise been long known. In 1871, in western Mexico, in the state of Sinaloa, another large iron meteorite was discovered, but little was known of its exact size and shape until Prof. Henry A. Ward, of Chicago, had the mass uncovered and examined. He found its dimensions to be: Length, 13 feet; width, 6 feet; and thickness, 5 feet. It has never been weighed, but estimates of its weight make it at least 30 tons. About equal in size to this, or perhaps a trifle larger, and if so the largest known meteorite, is the great mass usually known as the Peary meteorite. This, as is well known, was first observed by Lieut. Peary in one of his trips to Greenland, and in 1897 he made a special trip to procure it. This mass has a roughly spherical shape and weighs about 38 tons. On account of its shape, probably, it was known by the Esquimaux as the "tent." Two smaller masses near it were known respectively as the "woman" and the "dog." The dimensions of the large mass are 11 x 7 x 6 feet. It is preserved in the American Museum of Natural History in New York city.

One of the largest iron meteorites so far known was discovered near Willamette, Oregon, in 1902. In dimensions it nearly equals the large Peary mass, the dimensions being 10 x 7 x 5 feet. As it originally fell it was perhaps the largest iron meteorite yet known, but it has been greatly channeled and furrowed by the action of the atmosphere since its fall, so that its original weight has been greatly reduced. It probably, however, weighs at least ten tons. It has in the main a conical shape and was found pointed end down, showing that it fell in that position.

As regards the three great groups of stone, iron-stone and iron meteorites, the stone meteorites resemble in composition most nearly some basic volcanic rocks of the earth. Silica, magnesia and iron oxide are the chief components, with a little iron, nickel, potash and soda. The form in which these components appear as minerals is chiefly as chrysolite, bronzite, feldspar and metallic grains of iron and nickel. The color of stone meteorites is, as a rule, light to dark gray, though they sometimes become brown through oxidation. They are usually covered more or less with a crust resulting from the fusion of the surface and this is generally black in color. Most distinctive of all are the metallic grains scattered through the meteorite, a feature which terrestrial rocks do not exhibit. Another feature of the intimate structure of many stone meteorites never duplicated in terrestrial rocks is a constitution of little mineral balls. These balls, called chondri, vary in size from a dust-like minuteness to that of a pea. They do not exhibit a concentric and amorphous structure as the spherules of terrestrial rocks usually do, but are radiated and well crystallized. They usually consist of a single mineral and one common to the meteorite, such as chrysolite or bronzite. Sometimes the chondri make up practically the whole mass of the meteorite, or they may occur only here and there, the rest of the stone in such case often consisting of splinters and debris of chondri. The origin of the chondri is not understood. Some have thought that they represent a peculiar form in which the minerals of the meteorite have crystallized, while others regard them as having existed as individual bits of matter which by tituration acquired a spherical form and were later aggregated together. Stone meteorites containing chondri make up by far the larger part of stone meteorites known, but there are some stone meteorites which exhibit no chondri whatever. Most of these have a crystalline structure

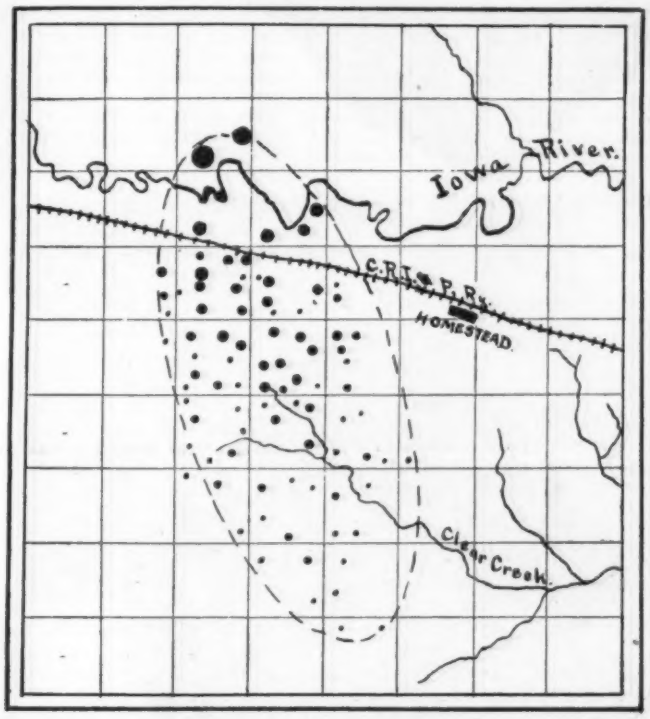


FIG. 1.—DISTRIBUTION OF HOMESTEAD METEORITE.

The stones fell in an ellipse 7 x 3 miles in area. The meteor came from the south, and the largest stones were carried the farthest.

closely resembling that of terrestrial volcanic rocks.

The iron-stone meteorites are distinguished from the stone meteorites by greater content of metal. This metal may be simply in the form of larger grains scattered through the stony material, or may form the framework of the mass and the stony minerals be held in it as in the pores of a sponge. In meteorites of the latter character the siliceous mineral is generally chrysolite.

The iron meteorites contain no silicates, only metal, with sulphides, phosphides and carbides of nickel and iron. The metal is chiefly iron, with which is associated from 5 per cent to 20 per cent of nickel, 1 per cent to 0.5 per cent of cobalt, and 0.02 per cent to 0.01 per cent of copper. Phosphorus, sulphur and carbon are almost always present in combined form. With iron and nickel these form the minerals tolilite, schreibersite and cohenite, which almost never occur in terrestrial rocks. The most interesting and peculiar feature of iron meteorites and one which distinguishes them from all terrestrial bodies, is the figures which they afford upon etching. If a smoothed surface of an iron meteorite be treated with acid, bromine water or other etching agent, there soon appear upon it regular figures. These figures have the appearance of a network of fine lines crossing each other at various angles. They run regularly through the mass of the meteorite except where interrupted by inclusions of other minerals. The figures are known as Widmanstatten figures in honor of Aloïs von Widmanstatten of Vienna, who first discovered them in 1808. They characterize the great majority of iron meteorites, though not all. When one of the surfaces showing figures is magnified further details are brought out. What appeared to be mere lines as seen with the naked eye prove on magnification to be broad bands of iron-gray color bordered on each side by narrower bands of nickel-white color. The former are called kamacite, the latter taenite. Analyses of the broad and narrow bands show that the narrow bands contain more nickel than the broad ones. They are, therefore, less attacked by the etching fluid and stand out in relief. There is also a third ingredient called plessite which fills the intervening spaces produced by the crossing of these bands and which is found to be intermediate in composition between the two other alloys. The structure indicated by these bands is crystalline, and the crystal form which the arrangement of the bands follows is that of the octahedron. Some iron meteorites, however, follow the planes of a cube rather than those of an octahedron and give figures of a different character.

Comparing the structures of the iron meteorites with those of the stone meteorites, we find that the iron meteorites are completely crystallized, the stone meteorites incompletely crystallized. If this crystallization has been acquired as the result of cooling from a molten magma, as seems probable, then the structure indicates that the stone meteorites cooled rapidly, the iron meteorites slowly. If the two kinds of meteorites were ever combined in one mass, as the unity of their constitution seems to indicate, such differences in rate of cooling would be likely to be produced if the iron were at the center of the mass, the stony on its surface. There are some reasons for believing that the earth may have a constitution of this character. The density of the earth as a whole is about twice as great as that of the rocks which form its crust. Its interior must, therefore, be more dense than its crust, either because of different constitution, or because of pressure. If the density is due to difference of constitution, it is quite likely that iron is the substance which produces it. In a list of the elements of the earth in the order of the abundance as we know them, oxygen takes first place, then comes silicon, aluminium, and iron. In meteorites, however, iron takes first place, then comes oxygen, silicon, and magnesium, while aluminium is present but in small quantity. The reason for these differences is probably that we are comparing, of necessity, only the constitution of the *crust* of the earth with that of meteorites. If we could compare the substance of the earth as a whole with that of meteorites, it is quite likely that they would be very similar. We have some reasons, therefore, for thinking that in meteorites we see the complete constitution of some sort of larger cosmic body. If meteorites do represent such a larger body what was probably its nature? Was it a moon, or a planet, or a body of some other character? The view that meteorites may have come to us from the volcanoes of the moon was quite widely held some years ago. The great craters of our satellite, some of them more than 100 miles in diameter, may indicate that great explosions may have occurred there at times. But astronomers have shown that if matter was shot from the moon, the chances of its ever reaching the earth would be too few to give us the great number of meteorites that we have. Further, the explosive force necessary to throw them out of the range of the moon's attraction would be greater than any that is likely to have existed. The same objections prevent our regarding meteorites as matter which has been shot from the volcanoes of the earth. Our big guns, 50 feet long, which throw a projectile weighing about a ton a distance of 21 miles, only give to the projectile a velocity of one half of one mile per second. In order to throw an object off the earth, however, a velocity must be given about fourteen times as great as this. Neither man nor earth, so far as we know, has ever produced such a projective velocity. Another difficulty which we would encounter in undertaking to trace the origin of meteorites to our earth would be that no terrestrial volcanoes, so far as we know, have ever ejected matter of a composition like that of the majority of meteorites. If neither the earth nor the moon produces these bodies, it is not likely that any of the bodies of our solar system could have done so, neither any of the fixed stars. Is there, then, any class of heavenly bodies to which we may ascribe a possible origin of meteorites? Our present knowledge seems to confine us to one if any, and to that by no means certainly. This one class of bodies is the comets. These are erratic celestial wanderers which have come into terrestrial view for a few hours or months, then disappear, perhaps to return in a few years, perhaps never to return. The size of these bodies is often remarkable. Such a one was Donati's comet, of which the head alone was estimated to have been 250,000 miles in diameter and its tail ten millions of miles in length. As it neared the sun great streamers shot out from its head and lay in filmy lines across the sky, often changing position and form. In other comets divisions and coalescences of the tail have been observed. Thus Borelly's comet when first seen had a simple tail. Two days later this subdivided into two and in two days more each of these divisions split in two. On the following day they coalesced again. Around the heads of comets are usually to be seen also luminous envelopes like the coats of an onion,

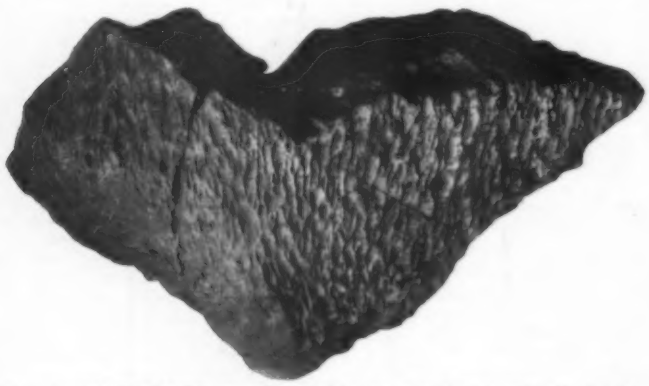


FIG. 2.—METEORITE WITH TYPICAL CONICAL FORM, LONG ISLAND, KANSAS.

Weight, 1,300 pounds. The form of the pittings and their radiation from the apex as here shown is also typical.

FIG. 3.—THE "PEARY" METEORITE, FROM CAPE YORK, GREENLAND.

Weight, 38 tons. Probably the largest iron meteorite.

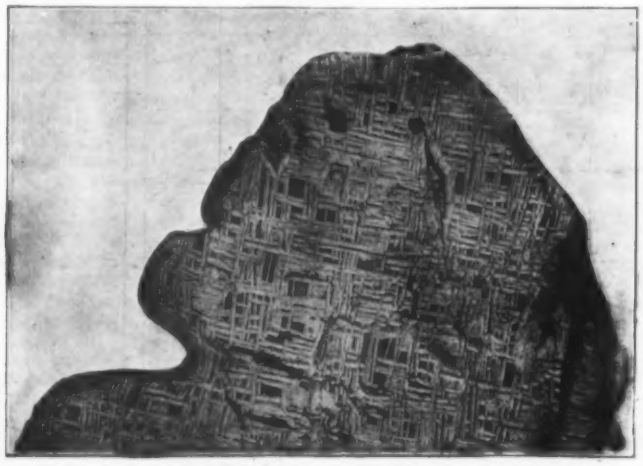


FIG. 5.—TYPICAL ETCHING OR WIDMANSTATTEN FIGURES OBTAINED BY TREATING A SMOOTH SURFACE OF AN IRON METEORITE WITH ACID.

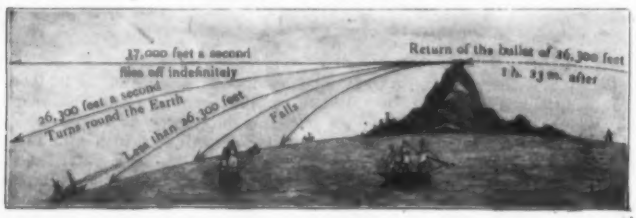

17,000 feet a second
flies off indefinitely
26,300 feet a second
Turns round the Earth
Less than 26,300 feet
Falls
Return of the bullet at 26,300 feet
1 h. 23 m. after

FIG. 6.—DIAGRAM SHOWING PATHS OF PROJECTILES OF DIFFERENT VELOCITIES.

FIG. 4.—TYPICAL METEORITE CHONDRUS AS SEEN IN SECTION UNDER MICROSCOPE. MAGNIFIED FIFTY DIAMETERS.

which peel off and disappear. All these observations show that the comets tend to break up and become dissipated under the disintegrating force, probably, of the sun's gravitation. One comet indeed, that called Biela's, was seen to break in two and has never been seen since, although the shooting star shower called the Andromedes has the same orbit and probably represents the disintegrated comet. Between other comets and shooting stars similar relations have been discovered. Thus the August meteors have the same orbit as Tuttle's comet, and the Leonids as Tempel's. The shooting stars thus seem to be the debris of comets. If meteorites are only large shooting stars, then there would seem to be good reason for regarding them likewise as cometary fragments. But meteors exceed shooting stars considerably in mass and are far more isolated in origin. They have higher velocities and do not group in times of fall with shooting stars. Moreover our knowledge of the mass and constitution of comets is not sufficient to warrant our asserting that they could produce meteorites. No comet has ever been observed possessing sufficient mass to cause a perturbation of movement in a larger heavenly body by its passage near it. Further, it is not unlikely that the constitution of comets is gaseous rather than solid. We are thus unable as yet to assert positively that meteorites are the children of comets. We can only say definitely in regard to them that they are solid fragments encountered in space by the earth and drawn in by the force of its superior attraction. When thus secured they give us the only tangible link which connects our earth with the vast areas of the universe beyond it.

THE QUEEN ANT AS A PSYCHOLOGICAL STUDY.*

By DR. WILLIAM MORTON WHEELER, American Museum of Natural History.

OBSERVERS of ant behavior have almost invariably fixed their attention on the easily procurable workers, to the all but complete neglect of the males and queens. In the case of the males, this neglect is, perhaps, pardonable, for the behavior of this sex is extremely monotonous. The neglect of the queens, however, as I shall endeavor to show, has not only left untouched a very interesting subject of study, but is responsible for much useless speculation.

Mention of the queen ant unfortunately suggests by association the idea of the queen honey-bee. These two insects are, however, in certain very important respects diametrical opposites. The queen honey-bee is a degenerate creature, unable to nourish herself or her young, to visit the flowers, build or store the comb; while the worker bee, apart from her normal infertility, still retains intact all the true female attributes of the ancestral solitary bees. In ants the very reverse of this is true: the queen is the perfect exemplar and embodiment of the species and has lost none of the primitive female attributes of independence and initiative, which she shares with the female bumble bees, solitary and social wasps. The worker ant, on the contrary, bears all the stigmata of incomplete and retarded development. Although these differences between the queen honey-bee and queen ant, and between the respective workers must be apparent to the most superficial observer, yet the familiar conception of the queen honey-bee as little more than an egg-laying machine, so degenerate that she cannot exist apart from the workers, has been tacitly expanded to embrace the queen ant. Surely it is time that the reputation of this insect should be viewed in a more favorable light.

Let us follow as briefly as possible the eventful life history of the queen ant. After more protracted larval and pupal stages than those of the worker and male—more protracted in order that she may store up more food and hence more energy in her body—she hatches as a sensitive callow in a colony at the height of its annual development. In other words, she is born into a community teeming with queens, workers, and males, and the larvæ and pupæ of these various forms at the season of their greatest activity and growth. From all sides a shower of stimuli must be constantly raining in upon her delicate organization as she tarries for days or even weeks in the dark galleries of the parental nest, while her color gradually deepens and her integument acquires its mature consistency. During this her prenuptial life, she may assist the workers in carrying about, feeding and cleaning the brood. She eats independently of the food brought into the nest by the foraging workers. She may occasionally join the workers in excavating chambers and galleries. If she belongs to a slave-making species she may even accompany the workers on their cocoon-robbing expeditions. Although she shows that she is able to perform all these actions supposed to be peculiar to the workers, she often does so with a certain desultory incoherency.

FIG. 1. Incipient Colony of Carpenter Ant (*Camponotus pennsylvanicus*), consisting of the queen, three minim workers and a packet of young larvæ, inhabiting the abandoned pupa case of a beetle (*Rhagium lineatum*) under pine bark. About natural size.

FIG. 3. Eggs and Fungus Garden in Cell of Queen *Atta sexdens* Forty-eight Hours after the Nuptial Flight. (After J. Huber.)

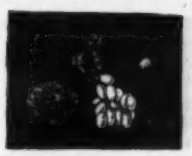


FIG. 4. Eggs and Fungus Garden in Cell of Queen *Atta sexdens* Seventy-two Hours after the Nuptial Flight. (After J. Huber.)

ism from the same source as the eggs, namely, from her fat-body and wing-muscles. The larvæ grow slowly, pupate prematurely and hatch as unusually small but otherwise normal workers. In some species it takes fully ten months to bring such a brood of minim workers to maturity, and during all this time the queen takes no nourishment, but merely draws on her reserve tissues. As soon as the workers mature, they break through the soil and thereby make an entrance to the nest and establish a communication with the outside world. They enlarge the original chamber and continue the excavation in the form of galleries. They go forth in search of food and share it with their exhausted mother, who now exhibits a further and final change in her behavior. She becomes so exceedingly timid and sensitive to the light that she hastens to conceal herself on the slightest disturbance to the number of mutilations, which, though occurring generation after generation in species that nest in hard, stony soil, are, of course, never inherited. In the cloistered seclusion of her chamber the queen now passes days, weeks, or even months, waiting for the eggs to mature in her ovaries. When these eggs have reached their full volume at the expense of her fat-body and degenerating wing-muscles, they are fertilized with a few of the many thousand spermatozoa stored up in her spermatheca and laid. The queen nurses them in a little packet till they hatch as minute larvæ. These she feeds with salivary secretion derived by metabol-

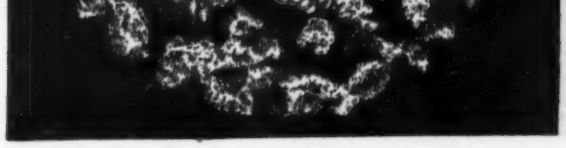


FIG. 7. Fungus Garden of *Atta sexdens* Fourteen Days after the Nuptial Flight. There are about 100 eggs which the queen has placed in a depression in the middle of the garden. Near the periphery there are three drops of the fecal liquid with which the queen manures the garden. (After J. Huber.)

When fully mature she becomes impatient for her marriage flight and must often be forcibly detained in the nest by the workers till the propitious hour arrives when the males and females from all the nests in the neighborhood rise high into the air and celebrate their nuptials. Then the fertilized queen descends to the earth and at once divests herself of her wings, either by pulling them off with her legs and jaws or by rubbing them off against the grass-blades, pebbles or soil. This act of deälation is the signal for important physiological and psychological changes. She is now an isolated being, henceforth restricted to a purely terrestrial existence, and has gone back to the ancestral level of the solitary female Hymenopteron. During her life in the parental nest she stored her body with food in the form of masses of fat and bulky wing-muscles. With this physiological endowment and with an elaborate inherited disposition, ordinarily called instinct, she sets out alone to create a colony out of her own substance. She begins by excavating a small burrow, either in the open soil, under some stone, or in rotten wood. She enlarges the blind end of the burrow to form a small chamber and then completely closes the opening to the outside world. The labor of excavating often wears away all her mandibular teeth, rubs the hairs from her body and mars her burnished or sculptured armor, thus producing a nest. She becomes utterly indifferent to the young, leaving them entirely to the care of the workers, while she limits her activities to laying eggs and imbibing liquid food from the tongues of her attendants. This copious nourishment soon restores her depleted fat-body, but her disappearing wing muscles have left her thoracic cavity hollow and filled with gases which cause her to float when placed in water. With this circumscribed activity she lives on, sometimes to an age of fifteen years, as a mere egg-laying machine. The current reputation of the ant queen is derived from such old, abraded, toothless, timorous queens found in well-established colonies. But it is neither chivalrous nor scientific to dwell exclusively on the limitations of these decrepit beldames without calling to mind the charms and self-sacrifices of their younger days.

FIG. 2. Head of Recently Fertilized Queen of *Atta sexdens* longitudinally bisected.

a, Mandible; *b*, labium retracted; *c*, buccal pocket, containing *d*, the pellet of fungus hyphæ carried from the parental nest; *e*, œsophagus; *f*, oral orifice. (After J. Huber.)

FIG. 5. Silhouette of a Queen *Atta sexdens* in the Act of Manuring Her Fungus Garden. A tuft of fungus mycelium is torn out of the garden, placed against the anus and saturated with a drop of fecal liquid. (From an instantaneous photograph, after J. Huber.)

FIG. 6. Silhouette of a Queen *Atta sexdens* Replacing the Saturated Tuft of Mycelium in the Fungus Garden. (From an instantaneous photograph, after J. Huber.)

Now to bring up a family of even very small children without eating anything and entirely on substances abstracted from one's own tissues is no trivial undertaking. Of the many thousands of ant queens annually impelled to enter on this ultra-strenuous life, very few survive to become mothers of colonies. The vast majority, after starting their shallow burrows, perish through excessive drought, moisture or cold, the attacks of parasitic fungi or subterranean insects, or start out with an inadequate supply of food-tissue in the first place. Only the very best endowed individuals live to preserve the species from extinction. I know

* From Popular Science Monthly.

of no better example of natural selection through the survival of the fittest.

It is certain that the colonies of most species are founded in the manner here described. It is certain, moreover, that all this is rendered possible by the nutritive endowment of the queen. As the winged germ of the species she has all the advantages that a yolk-laden has over a comparatively yolkless egg. Now among the 5,000 known species of ants we should expect to find considerable differences in the quantity of nutriment stored up in the young queen. And this is unquestionably the case. In some species the queens are of enormous size, in others they are very small compared with the workers. And since queens of average dimensions are able to start colonies by themselves alone, we should expect that unusually large queens would be able to accomplish even more, and very small queens less. This, too, is borne out by observation.

Unusually large queens are found in the genus *Atta*, a group of American ants that raise fungi for food, and are, so far as known, quite unable to subsist on anything else. The female *Atta* on leaving the parental nest is so well endowed with food-tissue, that she not only can raise a brood of workers without taking nourishment, but has energy to spare for the cultivation of a kitchen garden. She carries the germ of this garden from the parental nest in the form of a pellet of fungus hyphæ stowed away in her buccal pocket, spits it out soon after completing her chamber, manures with her excreta the rapidly growing hyphæ and carefully weeds them till her firstling brood of workers hatches. These then bring into the nest the pieces of leaves and the vegetable detritus essential to the maintenance and growth of the garden. The extraordinary habits of one of these fungus-raising ants, *Atta sexdens*, have been recently studied in great detail by Jakob Huber, from whose valuable paper I borrow a number of the accompanying illustrations (Figs. 2 to 7).

Very different is the condition of certain queen ants poorly endowed with food tissue—especially of some whose bodies are actually smaller than the largest workers of their species. Such queens are quite unable to bring up colonies unaided. They are therefore compelled, after fertilization, to associate themselves with adult workers either of their own or of a closely allied species. In the former case the queens may either remain in the parental nest and omit the nuptial flight, or return to the parental or to some other colony of the same species. In either case they add to the reproductive energy of an already established colony and thus prolong its life. If one of these poorly endowed queens, however, happens to alight from her nuptial journey far from any colony of her own species, she is obliged to associate with alien workers. And in this case, according to the species to which she belongs, one of three courses is open to her.

First, she may secure adoption in a small queenless colony of an allied species. Here she is fed, lays her eggs, and the resulting larvæ are reared by the strange workers. Eventually the alien workers die off and leave the queen and her own workers as an independent and sufficiently established colony, capable of rapid and often enormous multiplication. This is temporary social parasitism, first observed by myself in some of our American ants, but since found in some of the European species where I predicted its occurrence.

Second, the poorly endowed queen may establish herself in a colony of another species, but be unable, even after her workers have matured, to survive the death of the host colony, except, perhaps, by migrating to another nest of the same species. This is permanent social parasitism.

Third, the queen may enter a small colony of alien workers, and, when attacked, massacre them, appropriate their larvæ and pupæ, carefully secrete and nurse them till they hatch and thus surround herself with a colony of young and loyal workers that can bring up her brood for her without any drain on her food-tissues. This is the method of colony formation adopted by queens of the slave-making ants, as I have found by a number of experiments during the past summer. These queens thus manifest an instinct, hitherto supposed to be exclusively peculiar to the workers, namely, the instinct to rob the larvæ and pupæ of another species and bring them up as auxiliaries, or slaves.

Although the foregoing facts belong to ethology rather than to comparative psychology, it seemed necessary to review them before emphasizing their bearing on certain general questions. The behavior of the queen ant may be said to depend, first, on a relatively fixed inherited predisposition, or instinct; second, on inherited plasticity or adaptability; third, on constantly changing physiological states; and fourth, on stimuli which are partly primary and external and partly secondary, internal or true stimuli. These last are probably identical, as suggested by Jennings and others, with the physiological states, which in turn are evidently to be conceived as metabolic processes. That the queen ant profits by her prenuptial sojourn in the parental nest to learn by experience, tradition, and imitation, I have no doubt, but queens hatched in isolation show that this acquisition is insignificant in comparison with the inherited instincts. These appear as elaborate catenary reflexes, of which the reactions to light and contact stimuli may be taken as examples. In her callow stages the queen is negatively phototropic and positively stereotropic, but as the time for her nuptial flight approaches, these reactions are reversed, so that she seeks the light and avoids contact with the walls of the nest. After fertilization she again returns to the prenuptial condition—she shuns the light and tries to bury herself in the soil or under stones. These reactions, first described by Loeb, are as irresistible as they are adaptive. It can be shown, moreover, that these changes in tropisms are accompanied by changes in other instincts. My attention was first directed to the stereotyped character of these reactions in the queen ant by a simple experiment. I found that merely pulling off the wings with the tweezers caused the insect to pass at once from positive phototropism and negative stereotropism to the reverse. This shows that the change is not caused by fecundation, since artificially deälated virgin queens went through the complex catenary reflex of founding a colony with the same precision as fertilized individuals.

These and other observations, which I am unable to give in the space at my disposal, all point to constantly changing metabolic states as the mainspring of the queen ant's behavior. She is, in fact, a veritable chemical laboratory, in which we can see more clearly than in many other animals, a direct relation between behavior and the flux of metabolism.

I hasten over this matter to another general problem. The discovery that the queen ant really possesses, at least *in potentiâ*, all the instincts of the worker, besides others peculiar to herself, puts a different construction on a matter which has long been puzzling theoretical zoologists. It has been taken for granted that worker ants are necessarily sterile and that they possess morphological, physiological, and psychological characters not represented in the queens of their species. On such assumptions it is, of course, impossible to understand how the workers can have come by the obviously adaptive and exquisitely correlated characters, which they are unable to transmit. It will be remembered that neo-Darwinians and neo-Lamarckians, in the persons of Weismann and Herbert Spencer, locked horns over this matter some years ago. Both in this and in many similar discussions, the very premises which both parties accepted are unwarranted. In the first place, it is now known that workers readily become fertile when well fed, and that they can and often do produce normal young from unfecundated eggs. Although these young are usually, if not always, males, it is evident that these males, through the eggs which they fertilize, can transmit the characters of their worker mothers to succeeding generations of queens and workers. Thus the congenital, and perhaps even the acquired, characters of the worker are not necessarily lost; most, if not all of the characters of the worker are not qualitatively but only quantitatively different from those of the queen. In other words, the worker does not differ from the queen as a mutant, but as a fluctuating variation, which has been produced by imperfect or irregular feeding during its larval stages. This is true alike of morphological, physiological, and psychological characters. Even when the queen fails to manifest the worker instincts, we are not justified in doubting her ability to do so under the proper conditions.

The hitherto unsuspected capacity of the queen ant is beautifully illustrated by another set of facts, which at the same time show the close connection between adaptive behavior and regulation, or regeneration. Under normal conditions the queen, after rearing a brood of workers, no longer takes part in the "muck and muddle of child-raising" but seems to be as indifferent to the young of her species as some women who have brought up large families. If, however, the firstling brood of workers be removed and the queen isolated, she forthwith begins to bring up another brood, precisely as in the first instance, provided her body still contains sufficient food-tissue. She thus regenerates the lost part of her colony, just as a mutilated earthworm regenerates its lost segments. In the ant the absence of workers acts as a stimulus to restore the colony, just as the absence of segments leads the earthworm to complete its body.

The regulatory activities of the queen ant are, of course, highly adaptive and hence evidence of the variability which is so clearly manifested in the physical structure of these insects. There is no contradiction in the coexistence of such variability with the very stable character of certain instincts like those to which I have called attention, for an organism may be extremely plastic in some of its activities and rigidly conservative in others. It is evident that the remarkable variability of the female sex in ants—including under this term both the fertile, or queen phase, and the usually sterile, or worker phase—reaches its clearest expression in the extraordinary range of intraspecific polymorphism. In certain species, for example in the African driver ants (*Dorylli*) and American ants of visitation (*Ecitonii*), the structural differences between the workers of the smallest caste and the huge queen of the same species are enormous and represent an amplitude of variability in the female sex unequaled in any other organisms. Male ants, on the contrary, exhibit so little variability that it is often difficult, or even impossible, to distinguish the genera of single specimens of this sex. These facts have an important bearing on the views of authors like Brooks and Geddes and Thomson who assume that male animals are more variable than females, and of those authors who have transplanted this hypothesis to the fields of sociology and anthropology. All of these writers maintain a discreet and significant silence on the subject of the social insects. Equally astonishing, however, is the attitude of the biometricians, who, priding themselves on the accuracy of their methods and repudiating mere observation and speculation, proceed to an elaborate measurement of the wings of honey-bees and ants for the purpose of ascertaining whether males are more variable than females, when a glance at the personnel of a few ant and termite colonies would convince the most skeptical that there can be no such correlation between sex and variability as that assumed by the above-mentioned authors. If it is clear that the males of many of the higher animals are in certain characters more variable than the cospecific females, it is even clearer that the very opposite is true of the social hymenoptera, while in the termites, or white ants, both sexes seem to be alike variable and polymorphic.

(Concluded from SUPPLEMENT No. 1602, page 25666.)

CLEARING NEW LAND.*

By FRANKLIN WILLIAMS, JR.

TREES with an Indeterminate Root System.—There are several varieties of trees not only possessing a peculiar root system, but a wonderful capacity for reproducing themselves. On account of their wide distribution, common occurrence, and annoying character, it is deemed advisable to briefly advert to several leading specimens of this class.

Sassafras.—This is found most frequently in bush form. While it is occasionally observed growing to large size amid other forest trees, its favorite location is in old fields. Its chosen companions are hen grass, briers, and scrub pines. The growth for the first and second years is most vigorous; after that age very stunted.

The sassafras possesses a very singular root system. The roots strike perpendicularly into the ground for approximately 8 to 16 inches, then turn at right angles, rarely both ways, and pursue a horizontal course for about the same distance, when they split into numerous laterals.

Another and unfortunate peculiarity of the sassafras is the rapidity with which it reproduces itself. In this respect it resembles the asparagus vegetable. Indeed, after one has grubbed out this bush several times and observed how quickly and how numerously it reappears, he is forcibly reminded of the saying as to flies—for every one killed seven will return.

The usual custom of grubbing sassafras off several inches under ground serves only as a temporary expedient. While it will permit the plow to pass unmolested the first year, the next season and each succeeding one the mattock will have to precede the plow.

Constant and careful plowing and cultivation, if maintained for several years, will gradually exterminate this bush; but due regard for the condition of the soil will usually not permit such treatment. The improvement of the soil also tends to subdue the sassafras. Rich land does not seem to be congenial to it. It thrives best upon poor lands that are left idle at intervals.

The most satisfactory method of dealing with sassafras, if it is large enough, is to pull it out root and branch. Any clamp device, adjusted to a strong handle 5 or 6 feet long, and in such manner as to give strong leverage, will answer. There are such implements upon the market. They are most serviceable, not only in clearing sassafras, but for all other kinds of small bushes. This device can be used only on bushes of medium size. If too small the bush will break, and if too large the clamp can not take hold or the man power at the other end will not be sufficient.

The sassafras may be exterminated by one grubbing, if the root is followed and cut beyond where it makes the turn or angle, but this method is laborious.

Persimmon.—This species exists in various sizes over a wide range of territory. Its frequent form is that of a small, slender sapling. Its most common habitat is lowlands and swampy bottoms. In many particulars the persimmon is like the sassafras. Their root systems are practically identical. They are similar in their propensity for sending up sprouts when grubbed off in the usual manner, just under the surface. The lower limbs of both gradually die away as higher ones are thrown out. All trees are more or less given to this self-pruning process, especially if growing in close proximity with others, but this feature is very pronounced with sassafras and persimmon. It is evidenced even by small isolated bushes of these species.

The identity of root systems and similarity of throwing up shoots of these kinds renders it highly advisable when clearing to treat both alike. The several methods suggested for the eradication of the sassafras apply with equal force to the persimmon.

There are many old fields thickly set with small specimens of these two bushes. Such infestation if not wisely treated will prove a perennial plague. If the bushes are too small to admit of pulling by a hand grubber, then the best treatment for such fields is close pasturing. In lieu of that, frequent deep plowing with a sharp plow point will suffice.

Locust.—This variety, in some respects, is quite similar to the preceding. Its roots are usually nearer the earth surface, more numerous, attenuated, and tenacious than those of the sassafras and persimmon, but they pursue the same curious course. Cutting the locust off at or under the surface simply adds vigor to its offspring and increases its tendency to throw off more shoots.

The locust is valuable for timber purposes, and it is evident that is the mission for which it was created. Nature has not only given it a most difficult root sys-

* Farmers' Bulletin issued by the Department of Agriculture.

tem to subdue, but she has fortified its tops with numerous prickly thorns.

Beware of the locust tract. Tackle anything else in preference. But if it must be cleared, arm yourself with thorn-proof gloves and clothes and use the device recommended for pulling sassafras, or the horse-and-chain method advised for drawing saplings.

The Durability or Perishability of Stumps.—This feature of stumps manifestly and materially affects the problem of their removal. It is expensive to remove them, whatever method is employed, and if they are readily perishable it will be wise to leave their disposition to the processes of nature.

On the other hand, cultivation among stumps is slow and unsatisfactory, and if they are very resistant to decay it will be well to take them out.

The inclination of stumps to resist or succumb to the corroding effects of time are most striking and varying. For instance, the stumps of the locust and cedar are almost unaffected by the waste and ravages of age. He who cuts off such timber expecting the stumps to decay will wait in vain, for he will invariably pass away while the stumps still remain firm in their native fastness.

Stumps of the chestnut and white oak, if large, will, though not so durable as the locust and cedars, easily survive for a generation. While other species of the oak genus, the yellow poplar, and most species of the pine will soon perish, the white pine is, however, very durable.

When the durability of stumps renders their removal advisable, if they are large, it is well to wait a number of years after cutting away the timber until the smaller roots have rotted, when the stumps may be removed with much less labor. Meanwhile the land should be pastured or cultivated to keep down foul vegetation.

A Practical Illustration in Clearing Land.—In view of the various methods above referred to in clearing land and the varying conditions of the land to be cleared, it may be helpful to the reader to take a certain lot and describe from the beginning the clearing process to be pursued. In presenting such a practical illustration, however, we will not discuss the method referred to and sufficiently described under the heading of "Clearing by Pasturing." That method is, when time and circumstances permit, one to be highly commended, but it presents fewer difficulties than other methods, and hence the present illustration will deal with the other methods.

We will suppose a five-acre lot covered with a variety of wooded growth, as is usually the case, including white and black oak, chestnut, hickory, poplar, pine, and dogwood, varying in size from the small sapling to medium-sized trees, and the whole covered with more or less, perhaps considerable, underbrush. We will assume that the owner of this lot desires to use *this* land as soon as possible, and that, after due consideration of its soil and location, character of the growth covering it, and the probable cost of clearing the same, he decides that it will pay him to do so for the purpose he has in view.

The first step, regardless of what subsequent methods he may pursue, will be to select a dry time, probably in middle or late summer, to fire the underbrush and thoroughly burn over the lot. A good burning at this season will clear much of the small growth and consume the litter, both of which will be of considerable assistance in future treatment, whatever that may be.

Now, were the character of the growth on this lot fairly uniform as to the age and kind of timber, the undergrowth being burned away, a uniform method of clearing could be adopted to remove the timber still standing, but, as we have said, the growth varies in size from the small sapling to the medium-sized tree. The character of the timber includes more or less of the kinds and varieties referred to above under the head of taproot, indeterminate root, and lateral root systems. Consequently it will be necessary for the owner to resort to more than one means to effect a complete clearing of this land. After what has already been said with reference to the matter, it is obvious that the mattock and the ax must be provided and considerable dependence placed on these tools. The first thing to be undertaken should be to cut down those trees of a sufficiently large growth to make serviceable timber for firewood or other purposes, whose stumps may be allowed to remain in the ground, either because of their tendency to quickly rot and decay or because of their deep taproots, making the removal of the stump difficult and costly, bearing in mind also that the taprooted stumps offer comparatively little obstruction to the plow. In the case of trees of medium growth, of which, owing to the nature of their roots, the stumps must be removed, it will be well to dig down around the base, making a trench, as it were, around the tree, severing with an ax all roots extending laterally from the stump; if these remained unsevered they would serve to keep the tree upright. The trees thus treated will, for the most part, succumb to winds and storms, pulling up the stumps with them as they fall.

The next process will be to tackle the young saplings, as previously described, by means of a chain and team, pulling them out of the ground, stumps and all. Attention is called to the fact that where the stump has to be removed by pulling, whether in the way just described or by the stump puller, it is important to select for the purpose a day succeeding a wet spell or a thaw, when the earth is soft and wet for a considerable depth below the surface, a condition which will greatly facilitate the operation of stump pulling. As the work progresses it may be necessary from time to time to again resort to firing, burning worthless timber and litter, the timber designed for lumber or fuel having been previously removed and piled for future use.

At this time we have our lot pretty well cleared of standing timber, save such as has been left for the influence of wind and weather, and work must now be undertaken on such stumps as it has been found expedient to leave in the ground up to this time, but which from their position or nature it will be necessary to remove before undertaking to plow the land. In these cases the method indicated in Fig. 3 may be adopted, or the stump puller, if available, may be called into service. Possibly in a few cases, probably exceptional on this lot, recourse may have to be had to dynamite. Toward the spring those trees which have been dug around and which have succumbed to winter storms will in turn have to be removed. By pursuing systematically the course above set forth on a lot of the character indicated, the owner will doubtless have it in proper condition for the plow by the spring following the year in which he began the clearing.

Cultivation of New Land.—The quantity of roots remaining in the ground after it has been cleared is always surprising. No matter what clearing method has been pursued or how carefully it has been done, the plow will discover an aggravatingly large number of roots. When stumps are pulled out by machinery many more roots are removed than by any other method. But even in machinery-cleared land the ground will still be full of roots, mostly small, it is true.

In plowing new land a good, steady, strong span of horses is of the first importance. Horses that are fast or fractious will not answer. They will fret the plowman, break the plow, and bruise their shoulders. With a spirited team, even though nothing is broken or injured, it is hard to do good work. If the plow is drawn rapidly it is quite impossible to guide it closely and avoid stumps and roots.

After the winter season of comparative idleness horses should not be put to plowing new land. Their shoulders have grown tender from disuse and should be first gradually toughened in old land; moreover, some of their accumulated energy should thus be worked off.

Oxen Preferable to Horses.—For plowing new ground oxen are preferable to horses. They are steadier and stronger. Formerly in breaking new land it was a common occurrence to see several yoke of oxen attached to one strong plow; and they did yeoman service. Now, in this age of hurry and rush, the slow, plodding ox has been forced to give way to the faster horse, and when new ground is to be plowed unfortunately the ox is seldom at hand.

There are several patterns of plows made especially for new-ground work. These grub plows, however, while strong and handy, are not essential. Any standard plow with a good cutter properly and securely adjusted will do good work.

Cut Roots that Stop the Plow.—When plowing new land always have a mattock conveniently fastened to the plow handles, and cut all roots that do not break. When the plow becomes "hung" in roots it is better to cut it loose than to back and pull out. The root that stops the plow will interfere with cultivation, and the same root, unless severed, will occasion this annoyance for several successive seasons. In plowing new land it is well "to make haste slowly." Leave no skips. Turn a continuous furrow. The time saved in cultivating the crop, together with the increased harvest, will more than pay for the pains taken.

The second season the plow furrows should be run at right angles to those of the first. If these two plowings are thoroughly done, the ground will be completely broken and subdued.

If the land is very stumpy it will be quite difficult to level down for planting purposes. When the stumps are too thick for the old-fashioned A harrow to be used a heavy brush or cultivator, run opposite to the way the land was plowed, will answer fairly well. When the land is not too stumpy or the stumps are cut very low the spring-tooth harrow will do excellent work. The teeth will bound over stumps and roots that are fast and comb out a great many that are loose or broken. If the roots are plentiful, and they usually are, many of them will have to be removed. With an improved adjustable spring-tooth harrow, many of the loose roots may be combed out and windrowed and then burned or hauled off.

New Land Should be Cultivated for Successive Seasons.—In bringing new land under cultivation, cultivate for several successive seasons or until all roots are thoroughly broken and all foul vegetation completely destroyed. If cultivated for only one year and then seeded down or left idle any number of roots and small bushes will revive and start into renewed life.

Crops Adapted to New Land.—New land, because of the large quantity of vegetable matter it contains, is exceedingly loose. The leaf mold also gives the soil a dark color and fertile appearance. Humus or decomposed vegetation is an essential element in productive soils. It imparts a wholesome physical character and furnishes properties that enable it to retain heat, moisture, and plant food. But soils may contain too much organic matter, especially if it is not well decayed, hence virgin soil is usually not sufficiently productive at first for best crop results. Ordinarily, however, on new ground in the South each succeeding harvest will exceed the preceding one until the third or fourth year is reached. So that, in the long run, this excess of vegetable trash on recently cleared woodland tracts will, by its fertilizing value, and adding humus to the soil, more than compensate for the immediate loss in the earlier years.

Corn is a Good Crop for New Land.—New land is so aerated that usually crops growing on it suffer much for lack of moisture. It will generally produce a good growth of stalk, but the yield of grain will be poor. This is especially true of corn. If not overtaken by a severe drought the fodder will likely grow to good size, while the ears will be small and faulty. Corn, however, is a good crop for new land, not that it is especially adapted to such land, but because it is the easiest of all crops to cultivate on rough and rooty soil. The cultivation that corn requires is the very kind most desirable for new land. After several corn crops have been removed the land should be in good condition for any grass, cereal, or vegetable.

Oats should not follow corn on new land, or for that matter should not be seeded to any foul land, for they, especially spring oats, are the foulest crop upon the farm. The early spring preparation of the ground required for sowing oats serves as an excellent inducement to the vigorous growth of weeds, briers, and bushes; and the inability to cultivate oats during the growing season will enable this foreign matter to again secure a foothold.

Clover Well Adapted to New Land.—Among the grasses, clover seems best adapted to new land. Indeed, upon such soil it will invariably thrive, while upon old neighboring fields it may be difficult or impossible to secure a stand. In seeding new land to clover select the largest and most vigorous variety. The denser the growth the more difficult it will be for foul matter to secure a lodging; and the higher the clover stands the more shade it will afford, and this will facilitate the decay of roots and stumps. In fact, a most excellent treatment for new-ground pine land is to stir the surface with a harrow or cultivator and seed it to the large sapling clover. The clover will serve a most useful twofold mission. It will add nitrogen and humus to the soil and greatly assist in rotting the roots and stumps by the shade and contiguous decaying matter it affords.

Fruits of all kinds do well upon cleared woodland, provided, of course, that the location and mechanical condition of the soil are suitable. But it is not wise to plant trees on such land until it has been thoroughly plowed and is in a condition to be conveniently cultivated. In planting an orchard upon stumpy land, stumps should not be allowed to remain in proximity to the newly set trees. The stumps will not only interfere with cultivation but greatly endanger the trees by bruises from horse or plow.

Strawberries Make a Satisfactory Growth.—Among small fruits the strawberry thrives especially well on recently cleared land. Upon such soil it makes a most satisfactory growth and fruitage, and much less labor is required to keep the weeds and grass down, as the ground is not impregnated with foul seed. This immunity of new ground, compared to old land, from weed and grass infestation is a most important factor not only in strawberry culture but in all gardening or trucking operations.

New Ground is Desirable for Trucking.—For vegetable growing new land is very desirable, not only because of its comparative freedom from foul growth, but because such soils contain a large supply of organic nitrogen, the most necessary and expensive of vegetable fertilizers. It is light and porous, thereby enabling the tender sprout after germination to more readily push its feeble form through the earth's surface. Upon old land frequently a crust will form on the surface or the soil become baked, thereby preventing seed from coming up, but no trouble of this character is experienced with new ground. The physical condition of such soils greatly encourages the development of those tuberous vegetables that grow by a process of expansion under ground.

These are some of the properties of new ground that render it desirable for trucking. Potatoes, both sweet and Irish, will certainly thrive on this soil. They will yield well, be symmetrical in form, clear in color, and very free from scab. The tomato is another vegetable most congenial to new ground; upon such land it is relatively free from blight and less liable to be choked or smothered by a late summer grass, which so frequently appears upon old land after the size of the vines prevents cultivation. Neither should tobacco be omitted in enumerating crops adapted to new land.

Indeed, there is no question about the profitable cultivation of new land. The problem is when and how to clear it. When once the clearing has been completely accomplished the yield from such lands will be more satisfactory than the harvest from old fields. In fact, in many instances it would be wise and economical for the farmer to plant his old worn and washed fields to forest and clear other land for cultivation.

Dry Decomposition of the Phosphates.—Mr. Ch. Baskerville has succeeded in rendering assimilable phosphates in nodules by concreting the matter, ground fine with an alkaline carbonate. Four parts of the rock are mingled with one part of carbonate and heated to redness, until concretion is produced, but not fusion. The product is taken without trouble from the oven; it is in a porous state somewhat resembling pumice stone. It is readily ground and is not hygrometric. According to the temperature of the oven and the length of the time the matter is left in it,

from 75 to 90 per cent of phosphoric acid is rendered assimilable. He estimates that this process will be of special interest in countries like Sweden where sulphuric acid is comparatively dear, and deposits of carbonaceous and siliceous phosphates similar to those of North Carolina and those recently discovered in Japan are available.—Drogisten Zeitung.

THE ART OF INVENTING.*

By EDWIN J. PRINDLE, of the New York Bar.

THERE are many kinds of invention. The poet, the artist, the playwright, the novelist, all exercise or may exercise invention in the production of their works. The merchant may exercise invention in the devising of a new method of selling goods. The department store was an invention of this class.

The subject of my paper is, however, the art of making technical inventions, and particularly patentable inventions. And, first, of its commercial importance; for the engineer is concerned with things having a commercial value. By the art of inventing, wealth is created absolutely out of ideas alone. It usually takes capital to develop an invention and make it productive, but not always. A notable recent example is Prof. Pupin's loaded telephone line. He received a very large sum of money, and his expenditures, as I understand, were comparatively trivial.

The certificate of ownership of an invention is a patent, and the importance of the art of invention will be made apparent from a brief consideration of what rights a patent confers and of the part that patents play in the industries.

A patent is the most perfect form of monopoly recognized by the law. As was said in a recent decision:

"Within his domain, the patentee is czar. The people must take the invention on the terms he dictates or let it alone for seventeen years. This is a necessity from the nature of the grant. Cries of restraint of trade and impairment of the freedom of sales are unavailing, because for the promotion of the useful arts the constitution and statutes authorize this very monopoly."

There is an enormous amount of wealth in this country that is based upon patents. As an instance might be mentioned the fact that the United Shoe Machinery Company is, by means of patents, able to control the sewing machines upon which ninety per cent of the welt shoes in the United States are sewed. The Bell Telephone Company, the Westinghouse Air Brake Company, and many other corporations of the first importance built themselves up on patents. Patents have become so well recognized a factor in commerce that, in many lines of manufacture, concerns do not depend simply upon cheapness of manufacture, or quality of product, to maintain their trade, but they count on always having a product which is at least slightly better than that of their competitors, and which is covered by patents, so that they do not have to compete with an article of equal merit. And they keep a corps of inventors at work in a constant effort to improve the product, so that, when the patents now giving protection have expired, they will have a better article to offer, which shall also be protected by patents.

Inventing has become almost a recognized profession. Many large concerns constantly employ a large corps of inventors, at liberal salaries. Besides the inventors employed by large corporations, there are many inventors who have maintained their independence, and are free lances, so to speak. Some inventors have become wealthy almost solely by their inventions, such as Edison, Bell, Westinghouse, Marconi, Pupin, Tesla, and Sprague. A considerable number of the smaller manufacturing concerns are built largely or wholly upon the inventions of their principal owners.

Aside from the question of financial returns from inventing, the inventor has the satisfaction of knowing that he is a producer of the most fundamental kind. All material progress has involved the production of inventions. Inventors are universally conceded to be among the greatest benefactors of the human race.

The art of invention is therefore one of great commercial and economical importance, and it becomes a matter of much interest to know how inventions are produced. It is my object to attempt an explanation of the manner of their production.

If it be inquired on what grounds I offer an explanation of this apparently most difficult subject, I reply that, in the practice of patent law, I have often had occasion and opportunity to inquire into the mental processes of inventors, and that the subject is one to which I have given considerable attention.

It seems to be popularly believed that the inventor must be born to his work, and that such people are born only occasionally. This is true, to a certain extent, but I am convinced there are many people who, without suspecting it, have latent inventive abilities, which could be put to work if they only knew how to go about it. The large percentage of inventors in this country compared with all other countries, shows that the inventive faculty is one which can be cultivated to some extent. The difference in ingenuity is not wholly a matter of race, for substantially the same blood exists in some other countries, but it is the encouragement of our patent laws that has stimulated the cultivation of this faculty.

The popular idea seems to be that an invention is produced by its inventor at a single effort of the imagination and complete, as Minerva sprang full grown and fully armed from the mind of Jove.

It is, undoubtedly, true that every inventor must have some imagination or creative faculty, but, as I shall seek to show, this faculty may be greatly assisted by method. While reasoning does not constitute the whole of an inventive act, it can, so to speak, clear the way and render the inventive act easier of accomplishment.

Invention has been defined as "in the nature of a guess; the mind leaps across a logical chasm. Instead of working out a conclusion, it imagines it." The courts have repeatedly held that that which could be produced *purely* by the process of reasoning or inference, on the part of one ordinarily skilled in the art is not patentable, but that the imaginative or creative faculty must somewhere be used in the process. The mind must somewhere leap from the known to the unknown by means of the imagination, and not by mere inference in making the invention. But the inventor, consciously or unconsciously, by proper method, reduces the length of this leap to much more moderate proportions than is popularly supposed.

That reasoning and research frequently enter very largely into the inventive act in aid of the creative faculty is the opinion of Dr. Trowbridge, of Columbia University, who said:

"Important inventions leading to widespread improvements in the arts or to new industries do not come by chance, or as sudden inspiration, but are in almost every instance the result of long and exhaustive researches by men whose thorough familiarity with their subjects enables them to see clearly the way to improvements. Almost all important and successful inventions which have found their way into general use and acceptance have been the products of well-balanced and thoughtful minds, capable of patient, laborious investigation."

Judge Drummond, in a decision many years ago, said:

"Most inventions are the result of experiment, trial, and effort, and few of them are worked out by mere will."

Most inventions are an evolution from some previously invented form. It has been said:

"We know exactly how the human mind works. The unknown—or unknowable—it always conceives in terms of the known."

Even the imagination conceives in terms of what is already known; that is, the product of the imagination is a transformation of material already possessed. Imagination is the association in new relations of ideas already possessed by the mind. It is impossible to imagine that, the elements of which are not already known to us. We cannot conceive of a color which does not consist of a blending of one or more colors with which we are already familiar. This evolution of an invention is more or less logical, and is often worked out by logical processes to such an extent that the steps or efforts of imagination are greatly reduced as compared with the effort of producing the invention solely by the imagination.

Edison is quoted as having said that "any man can become an inventor if he has imagination and pertinacity," that "invention is not so much inspiration as perspiration."

There are four classes of protectable inventions. These are: Arts, machines, manufactures, and compositions of matter.

In popular language an art may be said to be any process or series of steps or operations for accomplishing a physical or chemical result. Examples are, the art of telephoning by causing undulations of the electric current corresponding to the sound waves of the spoken voice. The art of casting car wheels, which consists in directing the metal into the mold in a stream running tangentially instead of radially, so that the metal in the mold is given a rotary movement, and the heavy, sound metal flows out to the rim of the wheel, while the light and defective metal is displaced toward the center, where it is not subjected to wear.

The term machine hardly needs any explanation. It may be said to be an assemblage of two or more mechanical elements, having a law of action of its own.

A manufacture is anything made by hand of man, which is neither a machine nor a composition of matter; such as, a chisel, a match, or a pencil.

The term composition of matter covers all combinations of two or more substances, whether by mechanical mixture or chemical union, and whether they be gases, fluids, powders, or solids; such as a new cement or paint.

FIG. 1.
Time Stamp Record.

FIG. 4.
Hand and zero mark revolving within stationary dial.

9:23 FIG. 2. 10:15
Initial Time Stamp Record. Final Time Stamp Record.
Elapsed Time: 10:15—9:23 = 52 minutes.
Subtraction of hours and minutes of starting from hours and minutes of close required an operation exceedingly liable to error.

FIG. 3.
Subtraction eliminated but counting still required and uncertainty whether elapsed period is 7 or 53 minutes.

FIG. 5.
Initial imprint of zero mark alone and final imprint of hand (and zero). Elapsed time, 8 minutes. No subtraction and no uncertainty as to which imprint first, but counting still required.

* Read before the American Institute of Electrical Engineers.

These definitions are not legally exact, but serve to illustrate the meaning.

In the making of all inventions which do not consist in the discovery of the adaptability of some means to an end not intentionally being sought after, the first step is the selection of a problem. The inventor should first make certain that the problem is based upon a real need. Much time and money is sometimes spent in an effort to invent something that is not really needed. What already exists is good enough or is so good that no additional cost or complication would justify anything better. The new invention might be objectionable because it would involve counter disadvantages more important than its own ad-

FIG. 6.

Dial moved up to initial position of zero mark. Elapsed time, 11 minutes. No subtraction, no counting, no uncertainty; but only one record possible at a time.

vantages, so that a really desirable object is the first thing to be sure of.

Having selected a problem, the next step should be a thorough analysis of the old situation, getting at the reasons for the faults which exist, and in fact discovering the presence of faults which are not obvious to others, because of the tendency to believe that whatever is, is right.

Then the qualities of the material, and the laws of action under which one must operate should be exhaustively considered. It should be considered whether these laws are really or only apparently inflexible.

FIG. 7

Dial with pointer at zero revolving together.

It should be carefully considered whether further improvement is possible in the same direction, and such consideration will often suggest the direction in which further improvement must go, if a change of direction is necessary. Sometimes the only possible improvement is in an opposite direction. A glance at the accounts of how James Watt invented the condensing steam-engine will show what a large part profound study of the old engine and of the laws of steam played in his invention, and how strongly they suggested the directions of the solutions of his difficulties.

We now come to the constructive part of inventing, in order to illustrate which I will seek to explain

FIG. 8.

Dial with pointer at zero revolving together, zero mark on pointer being replaced by zero of dial.

how several inventions were, or could have been, produced.

The way in which the first automatic steam engine was produced was undoubtedly this—and it shows how comparatively easily a really great invention may sometimes be made. It was the duty of Humphrey Potter, a boy, to turn a stop-cock to let the steam into the cylinder and one to let in water to condense it at certain periods of each stroke of the engine, and if this were not done at the right time, the engine would stop. He noticed that these movements of the stop-cock handles took place in unison with the movements of certain portions of the beam of the engine. He simply connected the valve handles with the proper portions of the beam by strings, and the engine became automatic—a most eventful result.

As one example of the evolution of an invention, I will take an instrument for measuring and recording a period of time, known as the calculagraph, because it lends itself with facility to an explanation from a platform and because my duties as a lawyer have necessitated my becoming very familiar with the invention, and have caused me to consider how it was probably produced.

And first the problem: There was much occasion to determine and record the values of periods of elapsed time, such as the length of time of a telephone conversation, as the revenue of the telephone companies depended upon the accuracy of the determination. All the previous methods involved the recording in hours and minutes the times of day marking the initial and the final limits of the period to be measured, and then the subtraction of the one time of day from the other. This subtraction was found to be very unreliable as well as expensive. The problem then was to devise some way by which the value of the period could be arrived at directly and without subtraction and also by which such value could be mechanically recorded.

The prior machine from which the calculagraph was evolved is the time-stamp, a printing machine having a stationary die like a clock dial and having a rotating die like the hand of the clock, as in Fig. 1. The small

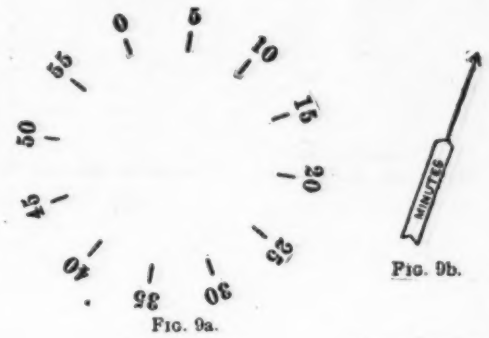


FIG. 9a. FIG. 9b.

Initial Imprint. Final Imprint.

FIG. 9c.

Complete Record.

Simple, direct-reading record. No subtraction, no counting, no uncertainty. Any number of overlapping periods recorded on one machine.

triangle outside the dial is the hour hand, it being placed outside the dial because it is necessary that the two hands shall be at the level of the face of the dial and yet be able to pass each other. The hour hand may be disregarded here, as the records needed are almost never an hour long. The manner of using the time stamp to determine the value of an interval was to stamp the time of day at the beginning of the period, and then to stamp the time of day at the close of the period at another place on the paper, as shown in Fig. 2, and finally mentally to subtract the one time of day from the other to get the value of the period.

The inventor of the new machine conceived the idea that, if the timestamp were provided with guides or gages so that the card could be placed both times in the same position, and the two records of the time stamp thus be superimposed concentrically (as illustrated in Fig. 3), the value of the period would be represented by the arc marked off by the initial and final imprints of the minute hand, so that, instead of subtracting one record from another, he had only to find the value of the arc marked off by counting the corresponding number of minutes along the dial.

The inventor had thus gotten rid of the subtraction, but there were several desirable qualities not yet obtained. First, he could not tell from the record alone, whether it was the longer or the shorter arc marked off that was the measure of the period. For instance, he could not tell whether the period was 7 or 53 minutes. This was because the two hand or pointer imprints were exactly alike except in position. So he conceived the idea of making the pointer imprints different in appearance, by providing the pointer die with a mark in line with the pointer, as illustrated in Fig. 4.

The mark and pointer revolve together and either the dies or the platen are so arranged that the mark can be printed without the pointer at the initial imprint and the pointer at the final imprint as in Fig. 5, the mark being printed or not at the final imprint, as desired. This could be done either by allowing the pointer die or the corresponding portion of the platen to remain retracted from the paper during the first printing.

It could thus be told with certainty from the record alone whether the longer or the shorter arc is the measure of the period, because the beginning of the arc is that indicated by the imprint of the mark without the pointer.

There was still something to be desired. The counting of the minutes along the measuring arc was a waste of time, if the value of the arc could in some way be directly indicated. If the hand were set back to 12 o'clock for the initial imprint, the final imprint would show the hand pointing directly at the minute whose number on the dial is the value of the period, and it would not even be necessary to count. But the setting of the hand back to zero would prevent its making the final imprint of any previously begun record, so that the machine could only be used for one record at a time. It was desirable to have a machine that would record any number of overlapping intervals at the same time, so that one machine would record the intervals of all the telephone conversations under the control of a single operator, or rather of two operators, because both of them could reach the same machine. So it wouldn't do to set the hand back to zero, as the hand must rotate constantly and uniformly. Then why not set the zero up to the hand at each initial imprint? This meant making the dial rotatable, as well as the hand. It gave an initial record like that shown in Fig. 6.

The inventor then thought of securing the dial to the pointer die so that they would revolve together, the zero of the dial being in line with the pointer, as illustrated in Fig. 7. This would obviate the necessity of setting the zero of the dial up to the pointer at the initial imprint.

But again the improvement involved a difficulty. As the dial rotated, its final impressions would never register with its initial impressions and would therefore always destroy them. As the first imprint of the dial was the only useful one, and as the second imprint only made trouble, the inventor conceived the idea of not making any imprint of the dial at the close of the period, and this he accomplished by making the annular portion of the platen covering the dial so that it could be advanced to print or not as desired. As the zero of the dial always marked the beginning of the measuring arc, it served the same purpose as the mark in line with the pointer, and the latter could now be omitted.

The final machine then consists simply of a revolving die which, as shown in Fig. 8, consists of a graduated and progressively numbered dial, having a pointer revolving in line with the zero, and the machine has a platen consisting of an inner circular portion over the pointer and an annular portion over the dial, each portion being operated by a separate handle so that the dial can be printed at the beginning of the period, and the pointer alone at its close.

The final record has an initial imprint of the dial, Fig. 9*a*, the zero of the dial showing the position of the pointer at the beginning of the period, and a final imprint of the pointer alone, as shown in Fig. 9*b*, the complete final record, Fig. 9*c*, consisting of the superimposition of these two records, and showing the pointer in line with that graduation whose number is the value of the period. Here is a record not only involving no subtraction and no uncertainty, but not even counting, in its record, and, as it was made without disturbing the motions either of the pointer or dial, any number of records of other periods could have been begun or finished while the machine was measuring the period in question.

Hiding all the intermediate steps in the evolution of this invention, it seems the result of spontaneous creation, but considering the steps in their successive order, it will be seen that the invention is an evolution from the time-stamp; that logic rendered the effort of the imagination at any one step small by comparison, and that the individual steps might be well within the capacity of a person to whom the spontaneous creation of the final invention might be utterly impossible.

(To be continued.)

WIRELESS TELEGRAPHY THROUGHOUT EUROPE.

ACCORDING to recent information in the German daily press the huge wireless telegraph station which is being erected at Norddeich for the German postal department, and which will be taken into operation on October 1, is to be the largest station of the kind in Europe, and is expected to control the whole of that part of the world. Experiments which have been conducted to test the efficiency of the new station, from a torpedo boat equipped with wireless telegraph apparatus, have given extremely satisfactory results, and are being extended to ever greater distance with the aid of the warship "München."

Three officials, who during last winter went through a special preparatory course at Berlin, have been working for three months at Norddeich.

A special feature is the mammoth trestle. No other structure of that part of the German coast (Ostfriesland) attains its colossal dimensions. Its height is 213 feet. It is composed of four iron towers of ex-

actly the same height, placed accurately at the angles of a large square, 213 feet from each other, so as to form an enormous cube. The bearing surfaces of these towers, which although entirely of iron, rest on insulating oak foundations, form equilateral triangles only 11.48 feet in length. At a height of 164 feet the towers taper to flat points which in common support the heavy collecting net beneath which the station proper has been fitted between the towers.

As the range of this station is to be a circle of 3,924 feet in radius, it is to cover practically the whole of Europe, the maximum distance being to Naples and St. Petersburg.

MALLEABLE CAST IRON.*

By G. A. AKERLIND.

IN 1722 Reamur published the fundamental principles for the malleable cast-iron process, but it is of comparatively recent years that the industrial world has utilized this knowledge. It was found that if a casting too hard to work were exposed to a continuous high heat for a number of days, imbedding in roll scale or iron ore, the casting would entirely change its nature, and at the time stated Reamur had collected those observations and found the principles which governed this change in the cast iron. The present generally accepted theory of the malleable cast-iron process is to decarbonize the metal by some oxide which will impart a portion of its oxygen to the carbon in the metal at a red heat, forming carbonic oxide, which is given off, thus extracting the carbon. The oxidizing reagents usually employed are roll scale and red hematite iron ore.

It is important that this material should be as free as possible from sulphur, which is the most objectionable substance in malleable cast iron. The theory as expressed above does not, however, seem to cover the field, as malleable castings are now produced without any decarbonizing material, the hard iron castings being packed in fire-clay or sand instead of roll scale or hematite ore. For small castings this treatment gives tolerably good results, but for heavier castings, tests and analyses show an inferior product.

Malleable cast iron is produced from hard or white castings. The furnace most commonly used in malleable foundries is of the reverberatory type, as this furnace has the great advantage of melting the charge without the fuel coming in contact with the metal. These furnaces vary in details of construction, but the accompanying illustration will give an idea of the general arrangement. The ash pit is inclosed and contains the air inlet from the blower. The grates are charged (commonly with good bituminous coal) through side doors, which are hermetically closed except at the time of charging. The flame passes the bridge and in some furnaces there is given an additional supply of fresh air forced through a number of small pipes and in the direction the gases travel. The hearth is slightly inclined toward the bath where the molten metal collects, and on this hearth is piled the charge to be melted. The roof immediately over the hearth is composed of a number of built up arches which are handled by a small traveling crane. In charging the furnace these arches are removed and when again placed in position all cracks or joints are closed with fireclay. A little above the high level of the bath are located on each side of the furnace rather small rectangular openings. Through these the events inside the furnace are observed, and wrought-iron bars are inserted for skimming off the slag and for "rabbling" or puddling the molten metal until the desired quality is reached. Beyond the bath is the "choke" and finally the smoke stack, about 75 feet to 100 feet high. At the bottom of the bath, on each side of the furnace, are located the tapping holes closed by a clay plug as in a cupola. The day's work is started by charging the furnace with pig iron, wrought iron scrap or old steel rails in such proportions as is deemed desirable for the castings to be made from the charge.

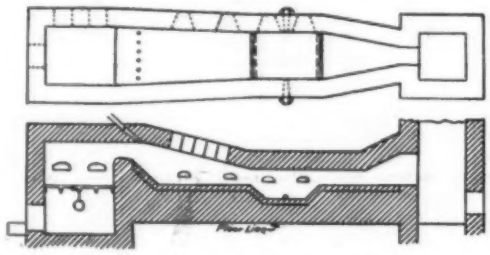
During the process of melting, which takes three to four hours, the grate surface is kept even to prevent cold air from entering the furnace, and when the charge commences to melt such parts as show a tendency to bake together are separated and led toward the bath where the slag formed is skimmed off so as to present a clean surface of molten metal to the frame in order to get the full benefit of the heat. After the charge is melted down the bath is vigorously "rabbled" or "boiled" to insure a thorough mixture, and to reduce the percentage of silicon to the desired point. This point is determined by dipping out a sample which is rapidly poured into a cast-iron mold, quickly cooled, and broken. If the fracture indicates the presence of graphitic carbon the "rabbling" is continued until a sample is procured whose fracture shows the desired composition or state of the metal. The tapping goes on from both sides of the furnace at the same time, and within about thirty minutes the whole charge is emptied and the furnace is allowed to cool down to receive a new charge.

The castings are removed from the flasks, the sprues and vents are knocked off and all cores cleaned out. The metal is now almost as brittle as glass, and some care has to be exercised in its transportation to the annealing house. Here castings of similar weight and sections are grouped together, and carefully "packed" in cast-iron boxes or frames varying in size to suit the articles to be annealed. The first one of these frames is placed on a cast-iron plate resting on two blocks in such a manner that the prongs of the hand-charging machine can enter under. The pieces to be annealed are placed so that they may be completely surrounded by the packing material (roll scale or red hematite ore), and care is taken that some parts of the castings project over the edges of the box, in this way forming a guide for the next section.

A pile about five feet high is formed in this manner, and when completed, removed by the charging carriage to the annealing furnace, where the piles are placed in rows so as to allow the flames from the fire grate free play. The opening of the annealing chamber is finally bricked up tight, and the fire started. These annealing furnaces are arched chambers about seven feet high by twelve feet deep and eight feet wide, with canals in the sides and under the floor so arranged as to convey the flames and the hot gases evenly through the rows of piles, and thus produce an even temperature. Natural draft is used, and the firing carefully moderated during the whole period of annealing from two to six days or more, depending on the character of the castings.

The temperature is brought up to a bright cherry red, or about 1,800 deg. Fahr. The furnace is provided with sight holes for observation, and the blue flames at the joints of the boxes give an indication of the process going on inside where the combined carbon leaves its union with the iron to combine instead with the oxygen, in turn loosened from its combination with iron in the ore or scale, forming carbon dioxide.

After the furnace is sufficiently cooled down, the temporary brick wall in the opening is removed, and the piles taken out by the charging carriage, and placed on the floor, where the now annealed castings are taken out and placed in the rattlers for cleaning. If the castings are small and of delicate construction they are cleaned by being placed in wooden vats containing a weak solution of sulphuric acid and "pickled." To neutralize the acid after the pickling process, these castings are finally washed in lime water. After the annealed castings leave the rattlers they are carefully examined for cracks or other defects, and if sprung out of shape they are hammered or forced by hydraulic power to the correct shape. Such parts as are produced in great quantities are placed in a drop hammer and one or two blows will insure its correct form. It may here be mentioned that nothing is gained by heating a malleable casting before hammering or forging it. A temperature of 50 to 100 deg. Fahr. seems to be satisfactory.



REVERBERATORY FURNACE.

I have endeavored to review the manufacture of malleable cast iron in its different stages, and I will now attempt to review some points which have a more direct bearing for the practical engineer or draftsman in considering malleable cast iron as a material of construction.

The tensile strength of malleable cast iron varies between 40,000 pounds and 50,000 pounds to the square inch, with an elongation in six inches of about six per cent to one per cent, and a reduction of area of about three per cent to three-fourths per cent, respectively. This, of course, is for a specially-prepared test piece of symmetrical form. Cast iron has a tensile strength of about 20,000 pounds to 30,000 pounds to the square inch, and is, therefore, about half as strong as malleable cast iron. This, however, refers only to tensile strength. For compressive strength cast iron is the stronger of the two, and compares very nearly with steel. The position of a casting in a machine is oftentimes such that the definite stresses are very difficult, not to say impossible, to determine; and the engineer is here left to his own judgment, based on experience or the precedence of similar cases. The reason malleable cast iron is used to such a large extent in car construction to-day is not only the constantly increasing demand for reduced deadweight, but still more the rapid supplanting of wood by steel and the consequent substitution of rivets instead of bolts. The ductility of the malleable casting very readily permits the driving of rivets, which cannot so readily be done with gray cast iron, and for certain parts of cars, like the journal boxes, malleable cast iron may well be considered to be supreme, leaving cast iron and "semi-steel" far behind, although for this particular detail lightness alone determines its use.

While white cast iron shrinks a great deal more in the flask than gray cast iron, and as the sections of malleable castings invariably are lighter than is the case in similar castings of gray iron, fractures are very common, and it is therefore one of the designer's very first considerations to so arrange and distribute the metal as to meet these conditions. In pieces of an elongated shape the stiffening ribs should extend lengthways so as to produce as little resistance as possible to the contraction of the metal at the time of solidification in the flask. If this be not possible, the molder provides a "crush core" with the exterior surface made of core sand in the usual manner, but whose interior is filled with crushed coke. This core barely stands handling, and when the metal solidifies in the flask it is crushed by the casting and thus prevents shrinkage cracks. At other times a certain corner or juncture of ribs in the casting will be found cracked. In order to prevent this a small piece of cast iron (chill) is imbedded in the sand at this critical point, and the metal will cool here more quickly than elsewhere, and thus fortify this particular point, although it may happen that some other part of the casting will be found fractured instead, and in many cases the locations and the shape of strengthening ribs in the casting must be altered until a casting is procured free from shrinkage cracks. Sometimes such defects do not appear until the casting is annealed, which, of course, entails a greater loss than if the casting had been scrapped before entering the annealing furnace.

In conclusion, let me summarize the points I would like to emphasize regarding the designing of malleable cast-iron details.

(1) Endeavor to keep the metal in different parts of the casting at a uniform thickness, depending on the size and weight of the casting. In a small casting, of say, ten pounds weight, one-quarter inch metal is about the practical thickness, five-sixteenths inch metal is about right for a casting of fifteen pounds to twenty pounds, and three-eighths to seven-sixteenths inch or one-half inch for castings of, say, forty pounds and over. This is for freight car castings, with which I am most familiar. For commercial reasons the demand for light malleable castings sometimes forces the designer to give such dimensions for thickness of metal in his casting that the foundry cannot make it successfully, or else the manufacturer will insist on a price per pound that will protect him for the extra expense in making it and the loss due to a high percentage of cracked castings. These losses sometimes amount to from ten to twenty per cent. It is therefore generally better policy to modify the design to suit the foundry, although on the other hand, these same commercial interests on your side have to be guarded as those prompting the foundryman to insist on a heavy, easy casting.

(2) Always endeavor to avoid sharp junctions of ribs or parts, and if the casting is long—say, 24 inches or more—bear in mind that the ends should be made of such shape as to offer as little resistance as possible to the contraction of metal when cooling in the mold.

If called upon to inspect malleable castings as to strength it is customary to break them with a sledge or under a "drop" and the difficulty of breaking them and the appearance of fracture forms the basis of opinion. A "good" casting will be found a pretty tough member to break. A fracture will show a distinct "skin" like wrought iron, while the interior is finely granulated, of a dark bluish color, without metallic luster. A "bad" casting is comparatively easily broken, does not show the skin, but does sometimes show a very dark bluish color, or in other cases a dark gray cast-iron fracture. This is generally attributed to "poor annealing," but if the metal in the furnace at the time of pouring does not have the right composition the resulting casting cannot be annealed. To guard against this it is sometimes practical for important castings to provide a small extension on a chunky part of the casting where the chilling effect of the molding sand would be least and break off this extension. The fracture will then show whether the metal is of the proper nature for annealing or not. It should be remembered, however, that there is such a thing as over-annealing—but in the present busy time this is hardly likely to occur very often.

As for patternmaking it may be mentioned that the common shrink rule, one-eighth inch per one foot longer than the ordinary rule, is used. Malleable cast iron shrinks more in the mold than gray cast-iron, but in the annealing process a slight swelling takes place.

The first pattern is made of wood, and from this the foundry patterns are made of aluminium, to which metal we are greatly indebted for the present growth in the malleable foundry business. Without aluminium patterns heavier castings could not be made economically, as the old-fashioned brass patterns required two or more men to handle them. A pattern shop in a malleable foundry is nowadays a far more comprehensive institution than formerly. The woodworking department is still here, but in addition a small foundry for the aluminium castings and a machine shop with planers, shapers, lathes, and drill presses, etc., will be found. As in most foundries the foreman patternmaker represents a great deal of "brains" of the establishment, and it is generally with him the engineer has to consult in regard to the feasibility of his design or overcoming difficulties developed in the making of a casting. The facts of the matter are that it is in co-operation by the individuals concerned in the actual production of a casting, a machine, or what-not, that the best results are obtained.—The Iron Trade Review.

* Abstract of a paper read at the April meeting of the Scandinavian Technical Society.

CONTEMPORARY ELECTRICAL SCIENCE.*

RESONANCE IN WIRELESS TELEGRAPHY.—Continuing his resonance researches, G. W. Pierce has passed from the electromagnetically-connected wireless telegraph circuits to the direct-coupled type. The sending station consisted of an auto-transformer instead of the Tesla arrangement of the previous experiments. The high-frequency oscillations in the sending antenna were produced by the discharge of a condenser through

* Compiled by E. E. Fournier d'Albe in the Electrician.

some of the turns of an inductance in the mast circuit, a form employed in several commercial systems. He finds that the resonance is by no means as sharp as it is in the electromagnetically-connected type. Tuning the receiver by a variable capacity shunted about the instrument, he found that with a constant sending circuit and a constant source of waves the current received in a circuit, brought to resonance by a capacity in shunt, is proportional to the square of the height of the receiving antenna measured from the "effective ground." The author proceeds to discuss the image theory, which supposes that the action in the grounded circuit with the receiving instrument near the ground is the same as it would be if, instead of being grounded, it should be symmetrically duplicated below the surface of the earth. Of course, in actual systems the grounding is not perfect, and, therefore, the symmetrical image gives only approximately an equivalent system. This theory was submitted to tests by comparing resonance curves with various forms of grounded circuits with the corresponding curves taken with an "image circuit" in the place of the ground. The results show a good agreement with the theory.—G. W. Pierce, Physical Review, March, 1906.

SPARKING AT BREAK.—Lord Rayleigh has discussed the relation between the energy given to the secondary of an induction coil when the primary current is broken and the velocity of separation of the contacts of the break of the primary. He showed, qualitatively, breaking the primary circuit by means of a rifle bullet, that in some cases a greater potential was produced in the secondary than when an ordinary break was used with its optimum capacity, and he came to the conclusion that if the break were made with sufficient abruptness, we might do away with the primary condenser altogether. J. C. Hubbard has further studied this question in the hope of finding relations between the constants of an oscillatory electric circuit, such as the primary of an induction coil, the initial current, and the velocity with which the contacts of the break are separated, when the conditions are just sufficient to prevent sparking at the break. By neglecting the "lag" effect in the spark, a theoretical relation was found, and may be roughly expressed by saying that the velocity of break necessary to prevent a spark will be proportional to the frequency of oscillation and a linear function of the maximum induced potential, the latter implying a linear relation between velocity of break and initial current. The necessary velocity of break was found experimentally to be: A linear function of the initial current; for given current, increasing in value in a manner consistent with the equation when the capacity is diminished; and diminishing according to the equation when the inductance is diminished. The assumption that the lag of the spark might be neglected did not hold true, but would do so if the time were great enough to allow the gas to be sufficiently ionized. The velocity of the break is lessened by any condition which causes the absorption of energy from the primary, such as a closed secondary, hysteresis, and heat losses.—J. C. Hubbard, Physical Review, March, 1906.

INTERNAL ENERGY OF ELEMENTS.—F. Soddy discusses the unknown store of energy contained in the chemical elements, and the prospect of making it available. Since all matter can be regarded as built up out of component elements, it is usual to regard the latter as the starting points from which the energy-content of all matter is reckoned, and, as a convention, to give all the elements zero energy-content. This, of course, as the chemical reactions sufficiently show, does not imply that the elements are devoid of energy. By a similar convention the earth is regarded as possessing zero potential. None of the material changes dealt with in chemistry are very profound. Radio-activity has brought more fundamental changes into view. The large internal energy exhibited by the radium atom cannot be regarded as peculiar to radium. Radium in its chemical properties is a completely normal and typical element, and possesses a chemical nature almost identical with the inactive element barium. Uranium was known long before its radio-activity was discovered, and represents another perfectly normal chemical element. Yet uranium, since it produces radium with evolution of energy, must possess all the internal energy of radium and more. It is probable that the elements as a class all possess great internal energy, and that their characteristics of stability and permanence, and the failure of all attempts to change them by artificial means, are due to the existence of this internal energy. The forces at our disposal compared to those which are exhibited when an atom suffers change, are of a different and lower order of magnitude, and it is not to be expected therefore that transmutation will become possible until we can control more powerful agencies than are at present available. Suppose that a way were known in which the element uranium, for example, which disintegrates to the extent of a thousand-millionth part annually, could be made completely to disintegrate in the course of a year. From 1 gramme of the element more than a thousand million calories could be evolved, and this, if it could be converted into electrical energy, would be equivalent to more than 1,000 kilowatt-hours, and would suffice to keep a 32-candle-power lamp burning continuously throughout the year. By the expenditure of about 1 ton yearly of uranium, costing less than £1,000, more energy would be derived than is supplied by all the electric supply stations of London put together.—F. Soddy, Paper read before the Glasgow Section, Institution of Electrical Engineers, March 13, 1906.

SCIENCE NOTES.

The production of caoutchouc by chemical means has, indeed, virtually been accomplished in its formation from isoprene. The exact nature of this change has still to be determined. When this has been done it will remain only to cheapen the cost of production to make the manufacture of synthetic rubber a purely practical problem. Still, the great extension of rubber planting which is now taking place is warranted by the present demand for the material. It has also to be remembered that the actual cost of producing raw rubber will probably be reduced, and the market price of rubber may eventually be so considerably lowered that, as with quinine, the synthetic production could not be profitably carried on. That is a question which involves many factors at present unknown, and only time can decide.

Mr. Strutt has shown, arguing from known data, that the maximum temperature at the bottom of a crust of about forty-five miles in thickness, must be in the neighborhood of 1,530 deg. C., although some amount of uncertainty is necessarily induced by our want of knowledge of the conductivity of rock at high temperatures. Anyhow, it is probable that at the depth indicated the temperature does not exceed the melting-point of platinum. Such a crust would contain about one-thirtieth of the earth's volume, and if throughout it the radium heat energy were of the average of that exhibited by many samples examined by Strutt, the temperature of the earth could be maintained until our stores of uranium suffered sensible depletion. Such an assumption would lead to the conclusion that the whole of the central portion of the earth consists of non-radio-active substances at an approximate uniform temperature somewhat below the melting-point of platinum.

M. Lancaster, director of the Belgian Meteorological Service, states that henceforward the results of the international balloon ascents organized by that service will be published in Ciel et Terre. Tandem "sounding" balloons made of India rubber are used, one of which bursts at a certain height; thermometers of two kinds are employed—Teisserenc de Bort's bimetallic instrument and Hergesell's German-silver cylindrical thermometer. In the ascents of April 5 and May 3 altitudes of 15,140 meters and 16,970 meters were attained, temperature —52.5 deg. C. and —38.0 deg. C. respectively. In the first experiment the lowest temperature recorded was —57.4 deg., at 13,500 meters, during the descent; an inversion occurred at 13,940 meters during the ascent. In the second experiment the lowest temperatures were —62.6 deg., at 10,160 meters, during the ascent, and —61.9 deg., at 9,800 meters during the descent. A large inversion commenced at 10,160 meters, and increased to 16,970 meters, when the upper balloon burst. Both ascents were made in the morning.

If we consider the numerous points of similarity between malaria and yellow fever they will be found to be very striking. Both are diseases of low-lying districts; both infections are contracted chiefly at night; both may be conveyed by direct inoculation of the blood of a patient; both are most prevalent in the places and seasons where and when mosquitoes are most numerous; both infections are impossible after severe frosts, which cause the mosquitoes to hibernate. These constitute strong points of resemblance between the two diseases, which differ from each other in that the duration of yellow fever is very short, while malarial infection may persist for years. Unfortunately, the parasite of yellow fever has never been found, in spite of claims to the contrary, and notwithstanding the use of the best powers of the microscope, and even the ultramicroscope, in the efforts of skilled observers to discover it. That there is a yellow-fever parasite we feel assured, because it is not possible to explain the continuous propagation of the disease upon any other hypothesis, and apart from its invisibility, the manifestations of its presence are in complete accord with the behavior of parasites that are well known. We must not forget that the minimal limits of creation in nature may be beyond our conception, and we must be prepared to learn, if necessary, that there are living bodies too minute to be defined with our present instruments.

A question of great importance to a community is the character of its water supply, and of equal importance to the individual is the purity of the water that is used in his household, whether it comes from a city main, or an isolated well in the country. That this was not always so considered hardly requires mention, for it is not a great many years since disease was considered a direct visitation of providence. The first investigation that attracted public attention to the fact that there might be a connection between the use of polluted water and disease may be said to be what is known in sanitary science as the "Broad Street Well Investigation." In the epidemic of cholera in London in 1854, the parish of St. James, Westminster, which in previous epidemics had suffered, on the whole, less than many other parts of London, suffered most severely, the death rate reaching two hundred in ten thousand. The whole parish was not equally affected, and the center of infection, or the special cholera area was in the neighborhood of Broad Street, and attention was drawn to the fact that, though city water was supplied to this district, a well situated on Broad Street was used to a very large extent for household purposes. An investigation followed and it was shown that of the deaths that occurred during the first week of the outbreak among persons living in this neighborhood, 82 per cent were known to have used the water from this well, and that houses and factories in the same radius where the water from this well was not used seemed to be exempt from the disease. A strong case between cause and effect was thus made out, and when a subsequent examination showed that there was direct leakage from an open privy into this well, it established as clearly as could be done by circumstantial evidence that the epidemic in St. James Parish in 1854 was caused by polluted water.

ENGINEERING NOTES.

Crude oil fuel is being used in the boiler plant of the Eagle Flour Mills at Newton, Mass., at a cost comparing very favorably with that of coal. About 170 barrels of oil are burned per week at a cost of from 3.99 to 4.69 cents per barrel of flour manufactured. The fuel cost when using coal averaged 4.6 cents per barrel of flour output, not taking account of the labor cost of handling the coal and stoking. The burner used is the Hammel crude oil burner, which uses steam for atomizing the liquid fuel, and no change was made in the furnace except to cover the grates tightly at the rear with bricks and sand, and at the front with half bricks laid loose with 1 inch air spaces; at the front close to the furnace doors an 8 x 12-inch air opening was left clear on either side. Combustion is absolutely smokeless when the burner is properly regulated.

Some remarkable railroad engineering has lately come to notice in Austria. For several years the Austrian government has been constructing a railroad from Salzburg to Trieste, the latter being one of the leading commercial ports of the Adriatic Sea. The general purpose has been to give a more direct outlet through this port to western Austria and south Germany. The new road is 128 miles long and is 150 miles shorter than the old round-about route. The road has been built in two sections, the first being from Salzburg, in western Austria, to Mallnitz, on the Southern Railroad of Austria, known as the Tauren Railroad; and the second is the Karawanken & Wochiner Railroad, by way of Klagenfurt, Assling, and Goricia to Trieste. The first section, the Tauren Railroad, passes over the Alps, and the completed road as far as Bad Gastein was dedicated by Emperor Francis Joseph last September. A second section was opened by the Emperor on August 4. The road is distinctly a mountain line, with the finest of Alpine scenery. The construction has involved no fewer than 48 tunnels and 728 bridges, about fifty of these being large structures. The bridges are nearly all of masonry arch construction.—Railway and Engineering Review.

At a recent meeting of the British Institute Mr. G. Gerald Stoney, M. Inst. C. E., dealt with the development in the use of steam turbines for driving dynamos and alternators, from the first one made in 1884 by Hon. Charles A. Parsons, C.B., F.R.S., of 10 horsepower, to the great ones of up to 8,000 horse-power used in the great power stations of Carville, Neasden, Chelsea, Paris, etc. He then described the further development of the steam turbine for driving rotary air compressors of the turbine type now largely used for blowing blast furnaces and other work, and pointed out the advantages gained of light weight, small foundations, small consumption of oil, and, above all, high economy of steam. These are generally for about 20,000 cubic feet free air per minute and a pressure of 10 to 15 pounds per square inch. A slightly different type is also made for about 30,000 cubic feet air per minute at about 1 pound per square inch pressure, which is used in several large iron works and elsewhere for dealing with the waste gases from furnaces and driving these gases through the recovering plant, etc., an important point being that they do not clog with tar and other matters. Since it is almost, if not quite, impossible to utilize economically low-pressure steam at about atmospheric pressure in a reciprocating engine, the exhaust steam turbine becomes of importance in many cases where there are non-condensing engines and other sources of exhaust steam. Several such installations were described.

The practice of running express trains over distances exceeding 100 miles without a stop upon British railroads is being extensively developed. At the present time there are some 150 of these "century trains" as they are called running in the daily schedules of the various trunk railroads in various parts of the country. The speed in nearly all cases is well over 55 miles an hour. The longest run is still carried out upon the Great Western Railroad between London and Plymouth, a distance of 225¾ miles, which also holds the record in point of speed, an average of 59.2 miles per hour being maintained throughout the journey. The Midland Railroad comes second with a non-stop run of 196¼ miles at an average speed of 56.1 miles per hour. The fastest booked running, however, is maintained upon the service of the Great Western between London and Bristol. The distance is 118¾ miles and the scheduled time for the journey is 120 minutes. In the majority of cases, however, this train runs well in advance of the booked time and invariably maintains an average speed of well over a mile a minute throughout the journey, one of the most noteworthy runs being made a few weeks ago, when an average speed of over 67 miles per hour was maintained. In connection with the recent accident upon the South Western Railroad to the American boat train at Salisbury, prior to this calamity only one life had been lost upon this system in a railroad wreck over a period of 17½ years, during which time 1,200,000,000 passengers had been carried.

TRADE NOTES AND FORMULÆ.

Fine Varnish.—In 1,000 parts of 95 per cent alcohol dissolve 65 parts of gum mastic and 250 parts of shellac. When completely dissolved stir and add 1/10 in volume of benzine; leave at rest for a few hours, and decant to separate the benzine.—Technisches Centralblatt.

To Harden Steel Tools.—Herr Gottlieb Kolb, of Mannheim, recommends a composition made of 100 parts of cupric sulphate (the essential ingredient), 300 parts of potassium cyanide, 700 parts of colophony, and 100 parts of linseed oil, for hardening tools made of steel.

Process for Rendering Sulphur Soluble.—This process, introduced in France by M. M. Champagne, consists essentially in mixing sulphur with resinous bodies, with alkaline products, or with the two kinds simultaneously. The resinous substances are not limited to any particular kind, either solid or liquid. For example, the following are made use of: rosin, colophony, aloes, and turpentine. As to alkaline products, carbonate of soda or potash may be employed, as well as soda or potash soaps.

A thorough and homogeneous mixture of sulphur in the sublimated state is produced, triturated, precipitated, or in any other form, with the substances selected.

The following is a sample: Sublimated sulphur, 154 pounds; carbonate of soda, 7 pounds; rosin in powder, 22 pounds. The materials are thoroughly mingled. The product obtained has the property of mixing intimately with water, forming a paste or broth, to which the desired consistency is given.

This product is said to allow of the ready employment of sulphur for treating certain maladies of the vine, by adding sulphate of copper and acetate of copper. A compound is prepared, which is useful for treating oidium, as well as mildew and black rot. For this purpose it is quite useful to render the sulphur soluble by its admixture with alkali or with a resinous substance and an alkali, for it can thus be used for neutralizing the acidity of the copper and the sulphate. The following are two formulas for composing a mixed product of this kind:

Liquid Product.—Take 2 parts by weight of the prepared sulphur, mix with 100 of water, and add 1 kilo of copper sulphate or other salt or a mixture of copper salts.

Solid Product.—Take 66 parts by weight of the prepared sulphur and mix intimately with 33 kilos of copper sulphate or other salt or a mixture of copper salts.

These products are then ready for use by simple solution in water in the proportion of 3 parts per 100 parts of water.

Process for the Fusion of Nickel.—The Zucker process, introduced in Europe, is conducted in the following manner: A bed of combustible is formed in a cupola and the fire allowed to burn for a certain time, say one hour, before the application of the blast. As soon as the current of air is in action, the nickel and a charge of combustible are added, preferably in this order, and as often as necessary to render the process continuous. Although the proportion of nickel with reference to the combustible may be varied, good results are obtained by employing at first equal quantities of granulated nickel; then, by employing alternating charges of combustible and nickel, in the proportion of about two-fifths of the combustible to three-fifths of nickel. After the first charges have been submitted to the current of air for about ten minutes, the nickel commences to run from the fire chamber, which is at white heat, and afterward flows continuously, as long as the charges of combustible and nickel are introduced. The melted nickel falls on a bed of fine sand, or into a suitable receiver, whence it can be drawn off or poured out at will.

The proportions which have given the best results in practice are the following: For the original bed of combustible, 121 pounds of coke and 299 of charcoal; for each of the first four charges following the introduction of air, 60.6 pounds of coke, 102 of coal, 159.5 of metal; for the following charges, 66.6 pounds of coke, 102 of coal, and 259.6 of nickel. The mechanism for the blast should preferably make 3,000 revolutions a minute and be of 18 horse-power. Various alloys may be added to the nickel before or after the fusion.

The fusing point of nickel, 1,590 deg. C., is about fifty per cent higher than that of iron, and the nickel must be submitted to heat for a much longer time than iron. It has been generally assumed that it is impossible to melt nickel with open fire, under the belief that nickel would escape without being melted, and that the product would be impure. Desirable results cannot ordinarily be accomplished by fusion in the cupolas, as it is impossible to attain in these ovens a sufficiently high temperature; on the other hand, the quantity of air furnished for the fusion of iron would not be sufficient for fusing and refining nickel. It has been found that the employment of large quantities of air, at high pressure, tends to oxidize the carbon, which can be absorbed by the nickel, and the heat becomes so intense that it brings the nickel, as said, to a state absolutely fluid and essentially pure. Castings of nickel thus obtained are perfectly free from air holes and pores and the grain is fine and compact. This quality is particularly desirable in constructing electrodes for nickeling.

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